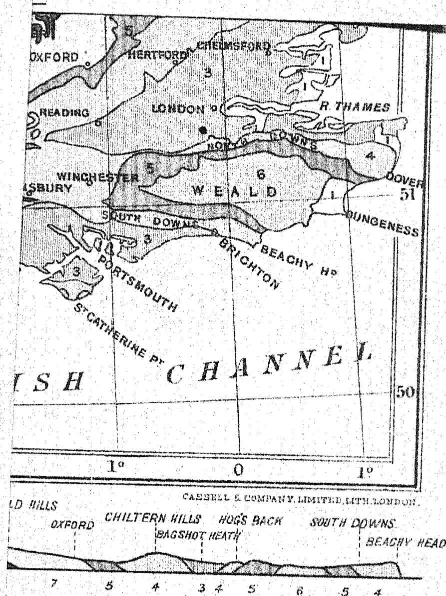

AND AND WALES,

TO BEACHY HEAD.

THIS WORLD OF OURS

AN INTRODUCTION TO

THE STUDY OF GEOGRAPHY

BY

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Author of "The Citizen Reader," "The Laws of Every-Day Life," &c.

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LA BELLE SAUVAGE

PREFACE.

A few words of explanation are required in placing this book before the public. The work was originally suggested by an admirable paper read by Mr. E. G. Ravenstein at the Royal Geographical Society in December, 1885. The title of the paper was the "Aims and Methods of Geographical Education," and the lecturer, with great clearness and force, pointed out the defects of the then accepted system of geographical teaching, and laid down the lines upon which the study of geography could most profitably and reasonably be conducted. He laughed at the useless expenditure of energy so often devoted to acquiring thousands of geographical names, and to turning the pupil for the nonce into "a walking gazetteer." "Walking gazetteers may have their uses, but their production ought not to be one of the objects of our schools." Moreover, information of the kind referred to, even if acquired, is almost immediately forgotten. Not content with negative criticism, Mr. Ravenstein gave definite and admirable advice as to the way in which geography should be taught. The unknown must be made intelligible by reference to the known; object lessons must accompany every stage in the instruction. The pupil must be made to understand that the various branches of geographical study are intimately connected one with the other. The Lecturer showed that political geography cannot be studied apart from physical geography; that commercial geography, apart from some knowledge of climatic conditions, is meaningless; that climatic phenomena can only be understood by one who has learnt to use the ordinary instruments by which temperature or barometrical pressure are recorded; that a map, regarded merely as a companion to a gazetteer, is not half understood, nor can its full value be appreciated, without some knowledge of the principles of map-making and a clear comprehension of the

relation between any given portion of the earth's surface and the printed plan in which its geographical values are recorded. These and many other valuable truths are to be found in Mr. Ravenstein's admirable paper. It was evident that, in the opinion of so high an authority, the time had come when it was absolutely essential that the ordinarily accepted methods of geographical teaching should be amended, and should be replaced by a more rational and a more logical system.

Being entirely of Mr. Ravenstein's opinion, I have endeavoured in the present volume to make some slight contribution towards remedying the deficiency to which he called attention. It is absolutely impossible, in the limits of a small book such as this, to deal exhaustively with any single one of the many branches of knowledge which make up the science of geography. I have not attempted any such exhaustive treatment. My object has been to give an idea of the *kind* of problems which are to be met with in a course of geographical study, to show their connection one with another, and to emphasise their bearing upon the life and occupations of human beings. I have endeavoured to draw the bulk of my examples from sources familiar to English readers; and the peculiar geographical circumstances of the British Islands make this task a comparatively easy one. The geographer in search of an ideal collection of object lessons could hardly select an area more replete with illustrations than that which is included by the "four seas." Washed by a great ocean stream; possessing a climate which presents almost every variety of temperature, with a geology which seems a compendium of the geology of the world; the centre of an empire which contains men of every race and products of every kind; with a history crowded with incident, chequered by innumerable changes, and yet continuous, England presents an ideal series of object lessons to the geographical student. I am quite aware that imperfect knowledge is in itself unsatisfactory, and that a mere smattering of information with regard to various departments of geographical study is of little value; but at the same time I am convinced that it is only by combining in a single volume references to many different matters that a beginner

can be made to realise that geography is the *sum* of the information which is to be obtained by those who follow out these various lines of research to their respective conclusions.

It is easy to devote a book to the study of English place-names and to that strange form of geographical information which tells the student that such-and-such a town, population 10,000, is situated on the river "So-and-So," and was the scene of a battle (A.D. 1203). Another book can as easily be filled with the elementary study of physics necessary for the complete comprehension of the principle of the barometer, thermometer, &c. History, geology, meteorology, anthropology, and a score of other subjects may each claim its separate volume or volumes, but I contend that it is a mistaken plan to allow a beginner to devote his mind exclusively to any one of these special branches. My object, therefore, has been to combine in a single book a series of chapters dealing with the various branches of geography, in the hope that by so doing the reader may be made to comprehend that the subject of his study is really a composite one.

The examples and illustrations are in many cases very elementary, and of course, from the scientific view, very inadequate. Every scientific man knows that between the rough apparatus which is sufficient to demonstrate a principle, and the perfectly accurate, and often very complicated, appliances which are necessary for the purpose of scientific observation there is an enormous difference. I am well aware, for instance, that observations at sea cannot for the purposes of navigation be taken in the rough-and-ready manner indicated in this book. Allowances have to be made, data which are the result of deep investigation and long study have to be utilised by the observer, and instruments of the highest accuracy must be called into requisition. But I am quite certain that if as a result of perusing these pages any of my readers turn their minds towards the study or practice of navigation, they will very soon find out for themselves what are the nature of my omissions. Meanwhile, if I have succeeded in making clear what is the basis of the calculation, what is the nature of the operation

which is to be performed, and what is the kind of problem which has to be solved, I shall be satisfied in what I have succeeded in achieving.

I have added at the end of the book a series of suggestions for the use of teachers, for, as Mr. Ravenstein most truly says, it is by "object lessons" and actual demonstration that geography can best be taught. How far each chapter is utilised as the basis of further instruction in the same subject must depend in every case upon the teacher. For one example that I have given, a hundred more can in most cases be added.

The greater part of the illustrations have been specially drawn for this work. I have purposely inserted in some of the chapters simple geometrical figures and elementary conclusions. Geometry is now taught in all our schools, and it is well to recognise at once that many geographical truths cannot be comprehended without some knowledge of geometry. On the other hand, I have endeavoured to make the language as simple as possible, and to illustrate every statement by a diagram or drawing.

In correcting this work for press I have had the most valuable assistance of Mr. G. Griffith, of Harrow, whose kindness I most gratefully acknowledge.

If I have only succeeded in impressing on any of my readers the fact of which I myself have long been convinced, namely, that the study of geography is one of the most fascinating that can possibly be undertaken, is one which can be followed with pleasure and profit at all times and in all places, which makes travelling a perpetual enjoyment, and staying at home a perpetual opportunity, I shall have achieved as much success as I have any right to expect or hope for.

November, 1891. H. O. A.-F.

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INTRODUCTORY CHAPTER.

Meaning of "Geography."

GEOGRAPHY comes from two Greek words—*gē*, the earth, and *graphein*, to draw or describe—and means the description of the earth.

We all know that there are many ways of describing both men and things, and the character of our description will vary according to the point of view from which we are looking at the person or object described. For instance, in describing a man we may consider him first as an animal, and from that point of view we shall describe his form, his size, his food, the shape of his bones, and the number of his teeth. Or we may consider him as a human being and as a member of society. We shall then describe his language, his habits, his temperament; we shall explain to what race he belongs, and from what part of the world he comes. Or, once more, we may consider a man from the point of view of the trade or occupation in which he happens to be engaged, and we shall then describe him as a builder, a lawyer, a schoolmaster, a labourer, or whatever he may be.

It is quite possible to describe the same man from each of these different points of view, and, indeed, from many others, and each description would be true as far as it went, although in order to have a full and perfect account of the man it would be necessary to combine all the different descriptions.

So it is when we come to describe the earth. There

are several points of view from which we may look at it, and the description we give will vary according to the point of view which we take.

As *Geographers*, or describers of the earth, we may look at it from several different points of view. Let us see what they are.

The Earth as a Planet.

In the first place, we may look at the earth as a planet revolving in space, a ball spinning round on its own axis, and at the same time moving in company with all the other planets round the sun.

At first sight it would seem as though the movements of the world in space were matters which concerned the astronomer only, and could have little or nothing to do with anything on the earth itself.

But a very little thought and a very little explanation will show us that it would be quite a mistake to exclude from the science of geography a study of the position and movement of the earth. In the first place, it is plain that, if it were only for the sake of completeness, it would be necessary for anyone who undertook to give a description of the earth to say something about its situation, its form, and its movements. It is a very incomplete account of an object which does not tell us where it is, what its shape is, and how it moves.

The Seasons.

In the second place, it is absolutely necessary that anyone who hopes to have a good knowledge of geography should be acquainted with the movements of the earth, and should know its shape and its situation. Without such a knowledge we should be unable to explain the occurrence of the **seasons—Winter** and **Summer, Autumn** and **Spring.** We should not understand the reasons of day and night, nor should we know anything of the causes of the climate,

which makes so great a difference in different parts of the earth's surface. We know that the heat of the sun is greatest near the equator or centre line of the earth's surface; we know that towards the poles there is eternal ice, and those who have only a slight knowledge of geography are aware that the northern half of the world has its summer in June, July, and August, while the same months in the southern half, such as the Cape of Good Hope, Australia, and South America, are a period of winter. But though we know these things, we should be quite unable to explain them unless we had studied the position of the earth as a planet, its movement round the sun, and its movement on its own axis.

Nor is this the only knowledge we acquire from looking at the world, as it were, from the outside. Many of the measurements of the surface of the earth can only be obtained by the help of observations of the sun and the stars. The shape of the earth itself has been discovered by astronomers—that is to say, by those who closely observe the stars and their movements,—and astronomers have calculated the weight of the globe.

It is plain, therefore, that geography, which, as we have explained, is a description of the earth, can never be completely studied apart from the study of the earth's position as a planet revolving in space.

Geography and Astronomy.

But in order to obtain a really useful acquaintance with this part of geographical science, it is necessary for the student to learn something of two very great sciences —namely, **Astronomy** * and **Geometry**.† Astronomy is

* Greek, *astron*, a star, and *nomos*, a law—the law of the stars.

† Greek, *gē*, the earth, and *metron*, a measure—the science of measuring the earth.

the science which deals with the laws regulating the movements of the heavenly bodies. Geometry means *measurement of the earth*, and is, as its name implies, the science of measuring distances upon the earth's surface, or through its bulk, or in space generally.

Now, both astronomy and geometry are very important and very interesting sciences, but like most other things which are worth knowing, they cannot be learnt without trouble and application, and it would be impossible in a small book such as this is to attempt to teach even the first principles of these two great sciences. Everyone who wishes to have a real knowledge of what geography means must learn something of astronomy and geometry, and until he has done so he must not think that he has really made himself a master of geographical science.

It is not proposed in this book to deal with this part of geography, which is one that requires special study. It is necessary, however, that this point of view should not be forgotten or overlooked.

It is a most important part of geography, and no one can claim to have a complete geographical knowledge of any part of the world unless he has studied the position of the earth as a planet moving in space round the sun.

Geography and Geology.

But there are other points of view which are equally important. It is the business of the geographer to describe not only the position of the earth and its movements, but also its shape, the materials of which it is made, and the way in which those materials have come to be arranged in their present form.

At this point the study of geography passes into the study of another science, which we know as that of **Geology**,*

* Greek, *gē*, the earth, and *logos*, science.

and which is concerned with the study of the arrangement, structure, and composition of the rocks which form the surface or crust of the earth. No one can have a really complete knowledge of the geography of a country unless he has made some study of the science of geology. It is well also for a geographer to have some acquaintance with **Mineralogy**—that is to say, the science which deals with the nature and composition of the various minerals, such as iron, limestone, granite, silica, coal, and so on, which are found in the ground, and which make up the earth on which we live.

Climate.

Then, again, in order to get a full description of any country, we must know something about its climate and about the causes which affect its climate, which make it hot or cold, wet or dry, healthy or unhealthy. And the moment we come to inquire into the question of climate we shall have to go farther and to study what is called the **Physical Geography** of the country—that is to say, the form and arrangement of its surface, the distribution of mountains and plains, the size and number and character of its rivers, and the depth of its valleys.

The Life of Animals and Plants.

And while we are learning the facts about such matters as these, we shall also naturally inquire into the distribution of plants upon the surface of the country. We shall ask what are the trees, the flowers, the fruits which grow within the district which we are studying. And lastly we shall come to a part of geography which is of very great importance and interest—namely, the distribution and the character of the human beings who live upon the surface of the earth.

The Life of Men and Women.

We shall see that the lives of men and women are affected in many different ways by the nature of the country in which they live; and we shall see also that in some cases, on the other hand, the whole character of the country itself is altered by the people who live upon it. And when we come to that part of geography which has specially to do with the lives of the people who live upon the earth's surface, we shall find that it falls into several natural divisions.

In the first place, there will be a question of climate and its effect upon the temperament, habits, and occupations of the people who are subject to it. And as the climate will necessarily make a great difference to the plants which grow upon the land and which supply food and occupation to the inhabitants, so also the actual form of the country and the nature of the minerals which are to be found in it will have a great effect.

Then, too, we must bear in mind that a great part of the lives of men is taken up in moving from one place to another, or in sending their goods from one place to another. The way by which men will travel, and by whi h they will send their goods, depends very largely indeed upon the geographical arrangements of those parts of the world through which they pass or through which they send their possessions.

Commercial Geography.

What is generally called commercial geography is principally concerned with the effect of the physical features of the world's surface upon the going and coming of its inhabitants and the sending backwards and forwards of their goods.

Geography and History.

At one point the study of Geography brings us very near to the study of **History**, for there can be no doubt that

the history of every nation has been very largely influenced by geographical facts, and no one can really understand the history of a country without knowing something of its climate and its physical features, whether it be mountainous or flat, hot or cold, situated near to the sea or far inland.

Art and War.

Two other great branches of the life of human beings depend greatly upon Geography. Almost ever since man has existed upon the face of the earth, **Art** and **War** have taken up a very large share of his interest and his time. It is quite certain that the art of every country has to a great extent been formed by the character of the country itself, and that poets, artists, and sculptors have owed a great deal of what has made them famous to the influence upon their minds of the mountains or the plains on which they lived: the snows or the suns, the sea breezes or inland gales to which they were accustomed. And when we come to the question of wars and war making, we find that so great has been the effect of the physical features of the earth's surface upon the fortunes of those who have fought their battles in all parts or nearly all parts of it, that **Military Geography** has become almost a science apart, and that many important books have been written devoted to this one subject alone.

The more we study the history of any great war, the more clearly shall we see that there was a reason for the spot on which almost every battle took place, and in two cases out of three it will turn out that the reason is a geographical one.

Statistical Geography.

And lastly, there is a part of Geography which, though not in itself very important, must be mentioned because it completes that full description of the earth, or of any

portion of it, which we said it was the business of the geographer to give. This part of Geography is what may be called **Geographical Information.** It is not really a science at all, but it supplies many of the facts which help us in really scientific geography. It consists in the study of the names, and positions, and populations of cities, towns, and villages; the rivers upon which different towns are situated, the names of bays, islands, continents, and so on.

These are things which every person who wishes to study the geography of a country must endeavour to learn. But it must not be forgotten that the mere learning of a number of names is not a real part of geographical science. To know that London is the capital of England and has four millions of inhabitants is a fact which it is useful to be aware of, but it is not one which the student of geography ought to rest content with. What he will want to know is *why* London is the capital of England, and *why* it has grown to such an enormous size; and if he makes himself really acquainted with all that Geography can teach him he will get an answer to these two questions.

SUMMARY.

1. Geography is the science of the description of the earth.

2. The earth may be described from many points of view, viz. :—

According to (*a*) its position,

(*b*) its movement,

(*c*) its shape,

(*d*) the material of which it is composed,

(*e*) the arrangement of its surface,

(*f*) the climate of different portions of its surface,

(*g*) the life upon its surface,

(*h*) the influence of its climate, arrangement, &c., upon the life of plants, animals, and men,

(*i*) their influence upon art, history, and war.

3. Statistical Geography is a part, but not the most important part, of geography.

Explanation of Terms.

Geography.—The science or knowledge of the earth.

Astronomy.—The science which treats of the heavenly bodies.

Geometry.—The science of measurement. Strictly speaking the word means science of measurement of the earth.

Geology.—The science which deals with the construction of the crust of the earth.

Physical Geography.—That part of the science of geography which describes the earth's features and explains their relation to each other. It deals also with climate, animals, and plants and their distribution, the ocean, &c.

CHAPTER II.

THE EARTH AS A PLANET IN SPACE. [1]*

The Earth is a Planet.

WE have said that among the different points of view from which the earth may be considered is that of its position as a **planet** moving with the other great planets, Jupiter, Saturn, and Mars, round the sun. To prove that the earth really is a planet, and to fully describe its position among the other planets, it would be necessary to make a careful study of the science of astronomy; and as there is not space here to attempt anything of the kind, we must be content to take for granted some facts which are undoubtedly true, but which at the same time we have not proved. When, however, we have once got so far as to admit that the earth is in reality a planet like the evening star, or like *Jupiter* and *Mars* which cross the heavens every day or night, we shall find out that there are a great many facts arising from this one fact which have much to do with the earth as we know it, and which make a great deal of difference to us who live upon it.

The Earth, its Shape and its Movement.

The earth is a globe revolving in space at a distance of about 93,000,000 miles from the sun, and it completes a circuit round the sun in $365\frac{1}{4}$ days † and it revolves once

* The numbers in the text enclosed in brackets refer to the notes at the end of the book.

† The exact period is 365 days 5 hours 48 minutes 49 seconds.

upon its own axis, that is to say it spins round once, in twenty-four hours.*

Though, roughly speaking, the shape of the earth may be called that of a globe, it is, in fact, what is known as an "**oblate spheroid**"—that is to say, a globe flattened at the top and bottom, and enlarged in the middle (see Fig. 1). We can picture to ourselves the earth revolving in its path or *orbit* round the sun, but in making the picture we must remember two facts which are necessary to make it correct. In the first place, although the earth goes completely round the sun, its path is not in a circle, but in a shape such as that shown in Fig. 2, which, as we

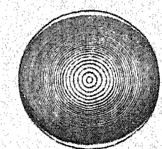

Fig. 1.—An Oblate Spheroid.

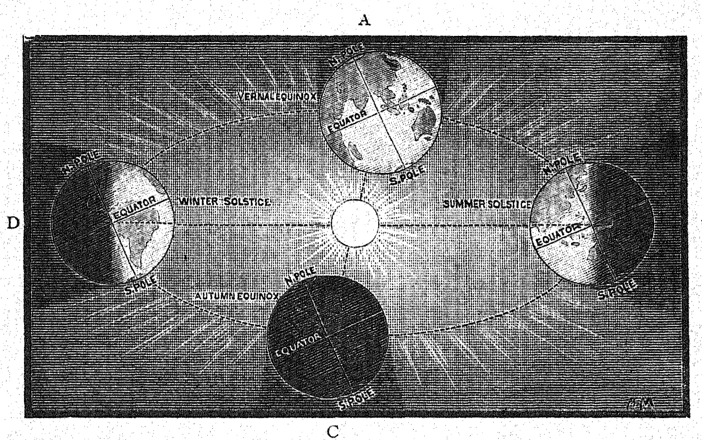

Fig. 2.—Diagram of the Four Seasons.

may see, is a curved figure longer one way than the other. This figure is called an *ellipse.* The other fact which we have to remember is that the axis of the earth

* The exact time is 23 hours 56 minutes 4 seconds.

as it spins along its orbit is not in an upright position, but is tilted or inclined at an angle as shown in the drawing, Fig. 3.

The broad line E which passes round the globe at an equal distance from the top and the bottom of the axis is called the **equator**. The two points A and B are known as the two poles of the earth, and the line which passes through them is the imaginary line or **axis** upon which the earth turns.

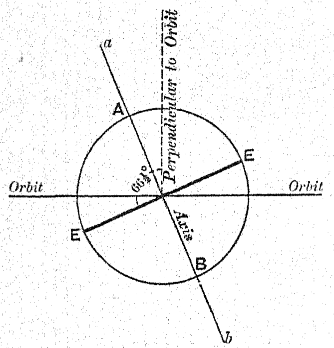

Fig. 3.—Diagram showing the Inclination of the Earth's Axis.

We can see that the line A B cuts the **orbit** or path of the earth round the sun at an angle, and if we measure this angle we shall find that it is one of 66½ degrees. We shall see that this fact makes a very important difference in our daily life.

The Shape of the Earth. How we know it.

We said that the earth was a globe, or nearly so. How do we know this fact?

We know it for several reasons, and we can prove it in several ways. In the first place, we know it to be a fact from observation of the earth itself. All who have been to the seaside will have noticed how a ship leaving shore gradually disappears over the horizon. First the hull, then the lower part of the masts, and finally the tops of the masts sink down in the distance. It is plain that the disappearance of the ship is not owing to the distance being too great for the eye to penetrate, for if instead

of remaining on the beach we climb up on to the cliff or into a tower by the shore, we shall once more see the hull or the masts of the ship which we had lost sight of when we were on the lower ground. In the same way sailors on the look-out at sea are sent to the top of the mast, and from there they can see the land or other ships which were invisible to them from the deck. As the sea song runs,

> "The sailor sighs as sinks his native shore,
> And climbs the mast to feast his eyes once more."

From these facts we are able to conclude that the earth is at any rate not flat. Fig. 4 explains better than a

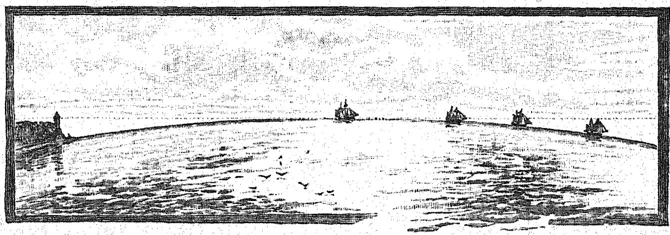

Fig. 4.—Diagram illustrating Curvature of the Earth's Surface.

description how it is that the ship gradually disappears over the horizon. It has, in fact, followed the line of the earth's surface, and that surface, being round, has soon come between our eye and the object at which we were looking. Thus, by **observation of the earth itself** we know that its surface is curved.

What the Moon Tells us.

That the earth is round, or nearly so, we learn in another way also; that is to say, by the plan of comparing a thing which we do not know with a thing which we do know. We look through a telescope, and we see the moon

or the planets moving through the sky; and astronomers tell us that from the observations which they make, they

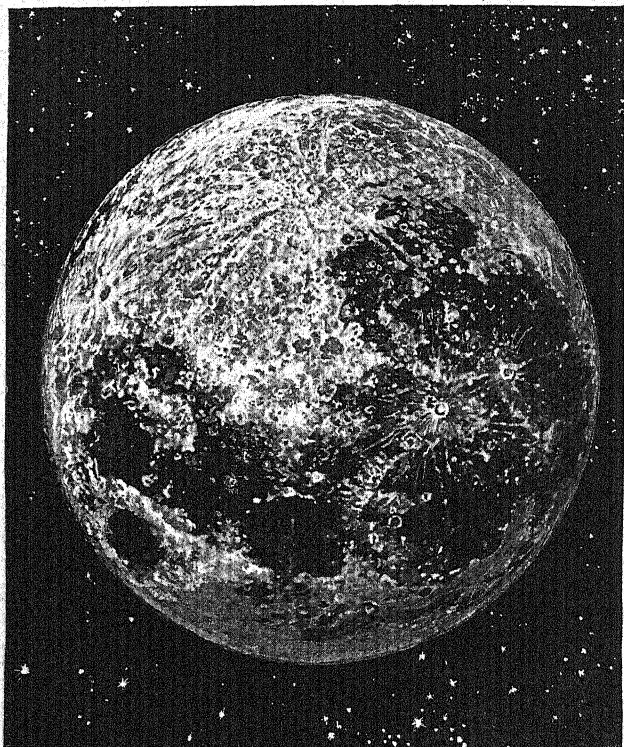

Fig 5.—The Moon as Seen through a Telescope.

learn that the earth, the planets, and the moon resemble each other in their movements, and in a great variety of other circumstances, and that there is the strongest possible reason to believe that the earth is a body very similar to the

planets which we can see. Now, that the planets which we can see—or the moon, which we can see still better—are globular, there can be no doubt at all; our own eyes convince us of the fact.

Fig. 5 is taken from a photograph of the moon as it appears to an observer looking through a telescope. There can be no two opinions as to what the shape of the moon is. It is a big ball or globe. If, then, we are convinced that the earth is a body similar to the planets or to the moon in most respects, it is reasonable to suppose that it resembles them also in shape, and to say that, like them, it is a **globe**.

The Teaching of the Shadow.

That the earth is round, or nearly so, we also know in another way. We cannot, it is true, look at our own earth from the outside as we can look at the moon and the stars; nor can we look at our own faces, but what we can do, and what many of us often do, is to look at our own reflection in the glass, or the shadow of our own face upon the wall. And it so happens that nature has provided us with a method of looking at the shadow of the earth. Whenever the earth happens to come directly between the sun and the moon, it stops the rays of the sun from reaching the moon, and as a result, all that part of the moon which is directly behind the earth is thrown into shade. If a person puts his face between a candle and a wall, a shadow will be thrown upon the wall (Fig. 6), and we know for certain that **the shadow represents the shape of the object which casts it**—that is to say, of the face which intercepts the light. In the same way, the shadow which appears upon the moon tells us with perfect certainty the shape of the object which throws it. The object which throws it is the earth, and, as everybody knows who has ever watched an eclipse of the moon, that shadow tells us perfectly plainly that the **earth is round.**

Round the World in Eighty Days.

And lastly, there is another way in which we get to know for certain that the earth is a globe. It is a very simple way, and it consists simply **in going round the earth** and finding out the fact for ourselves. There is a story

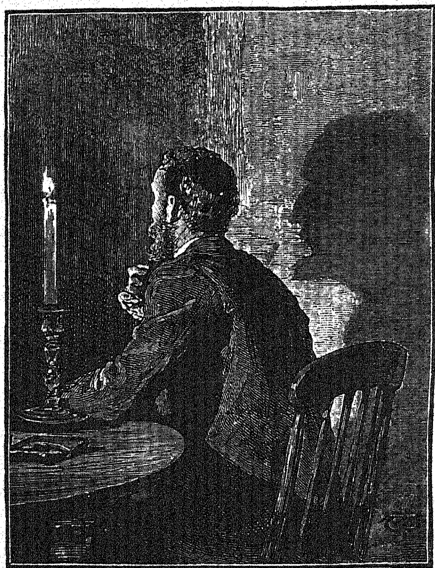

Fig. 6.—The Form and the Shadow.

which is now very well known under the title of "Round the World in Eighty Days," and this story only tells us of a fact with which we are all perfectly familiar nowadays—that it is possible to journey round the earth and come back to the spot from which we started.

But this is only half a proof, for, of course, the fact that we can travel round the earth does not prove that it is a

globe; it might be a *cylinder* (see Fig. 7). In that case, we should be able to travel round it in any part, and at whatever part we travelled round it the distance would be the same. As a matter of fact, the distance round the world in any part of it is not the same by any means. A person starting to sail round the world at the equator would

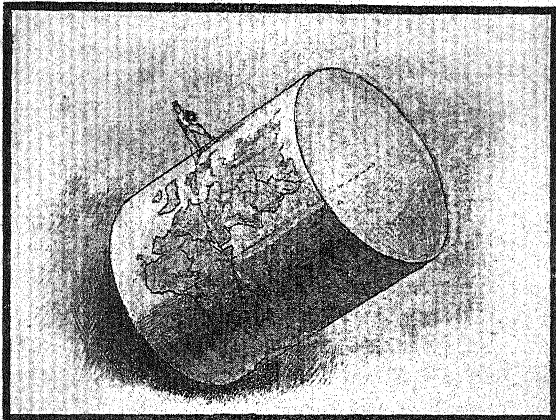

Fig. 7.—The Earth represented as a Cylinder.

take far longer to come back to where he started from than a person who started from Liverpool, which is 3,700 miles north of the equator and over 2,500 miles from the north pole. This is not only a matter of theory, but it is a fact which every practical sailor knows quite well, and we see the explanation of it in a moment when we remember that the earth is not a cylinder, but a globe.

It is plain that the distance round the globe in Fig. 8 at the point A is greater than the distance round it at the point B, and, in the same way, the nearer we get to the pole the shorter will be the distance round the globe; so that

if we got to the pole itself we might walk round the world in as short a time as it takes us to turn round.

The Shape and Position of the Globe.

We saw just now that our two general descriptions of the earth, as revolving on its own axis and of being a globe, were not quite correct or clear without some further explanation. We said that the earth, instead of being a globe, was an *oblate spheroid*—that is to say, a globe flattened at both ends and bulged in the middle. We get to know this fact in various ways. In the first place, we get to know it from observing other planets, which have the same shape; in the second place, we find that the effect of spinning a globe rapidly round on its own axis is to flatten its top and to bulge it out in the middle. This experiment has actually been tried with globes of different materials, and reasoning from what we know to be true in one case, we are led to believe that the same law will apply to the earth as applies to other objects of the same character and in the same position.

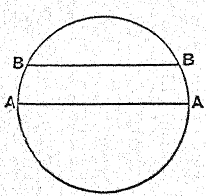

Fig. 8.—Short and Long Circles.

And lastly, we learn that the earth is not a perfect globe in a very practical way, and that is, **by actual measurement.**

So, too, we learn from a long series of observations that it is true that the earth revolves on an axis which is inclined at an angle of $66\frac{1}{2}$ degrees to its orbit.

The question of how we measure the earth and the question of the consequences which follow from the inclined position of the earth are very important, and have a very important bearing upon the study of geography; we shall therefore consider them separately in another chapter.

SUMMARY.

1. The earth is a planet revolving in space, like the other planets—Jupiter, Saturn, Mars, etc.—which we see in the heavens.

2. The earth is an oblate spheroid revolving round the sun in rather less than 365¼ days, and revolving on its own axis once in 23 hours 56 minutes 4 seconds.

3. The axis of the earth is inclined to the orbit at an angle of 66½ degrees.

4. We know the earth is a globe—

(*a*) By observation of the earth itself.

(*b*) By comparing it with the moon and with other planets.

(*c*) By observing its shadow.

(*d*) By going round it.

(*e*) By measuring it.

EXPLANATION OF TERMS.

OBLATE SPHEROID.—A globe flattened at the poles or top and bottom.

ELLIPSE.—A curved figure produced by the intersection of a cone by a plane which passes through it obliquely. If two pins are stuck in a piece of board or card, and connected by a thread which is allowed to hang loosely, and a pencil inserted in the loop and moved round the pins, the figure traced will be an ellipse. The difference between an ellipse and an oval should be noted.

AXIS.—The straight line passing through a solid body on which it revolves, or may be supposed to revolve. The earth's axis is the line connecting the two poles.

ORBIT (the earth's).—The path or track on which the earth revolves round the sun.

CYLINDER.—A body shaped like a roller.

CHAPTER III.

THE POSITION OF THE EARTH.— SUMMER AND WINTER.

The Inclination of the Earth, and its Effects.

WE saw in the previous chapter that the earth's axis does not stand upright while moving on its path round the sun, but that it is inclined, the north pole being tilted one way, and the south pole the other (see Fig. 3, p. 12).

Now it is to this tilting or inclination of the globe that we owe some very important facts, of which we are all of us well aware, but for which we are not all equally able to account. We all know that it is hotter in summer than in winter, that the days are longer in summer than in winter, and that the nearer we get to the equator the hotter it becomes, while as we move towards the pole it becomes colder and colder, till at last we come to a region of perpetual ice.

Day and Night, and the Seasons.

What is the explanation of these facts?

To understand them we must go back to our picture of the earth revolving in its orbit round the sun (Fig. 2, p. 11). When the earth is opposite the sun at A or at C, the whole of one side from the north pole to the south pole of the earth will be equally lit up, both in the northern and in the southern half of the globe.

The globe, as we know, turns round once in twenty-four

hours, and for twelve hours, therefore, a place on this half of the globe will be turned towards the sun—that is to say, will be in *daylight*—and for the other twelve hours it will be turned away from the sun—that is to say, it will be in *night*. The day will be twelve hours long, and the night will be twelve hours also; that is to say, day and night will be equal. This is what we call the time of the **equinox**,* which, as we know, occurs in the spring and in the autumn; but if we look at the globe represented at B or D, we shall see that it is in quite a different position. This is because the earth is *inclined* to its orbit, and *not perpendicular*. When the earth is at B, the north pole is inclined inwards towards the sun, while the south pole is turned away from the sun altogether. The sun shines not only on to the top of the earth, but over the north pole, lighting up a portion of the other side. We can see that the line which divides the bright from the shaded part leaves a great deal more of the northern half of the globe in the sunshine than of the southern half. The nearer we get to the north pole, the sooner shall we come into the sunshine out of the darkness, until, when we get near the pole itself, the sun shining down on the top of the globe will give light *for the whole twenty-four hours during which the earth is turning round.*

On the other hand, if we go south from the equator or the middle of the earth, the portion of the earth's surface which is in sunlight becomes smaller and smaller, until, when we approach the south pole, we come to a part which is altogether turned away from the sun, and which *for the whole twenty-four hours is hidden in night.* We can easily understand that this must be the position of the earth when we in the northern part of it are enjoying our long summer days and short summer nights, and when our friends in Australia, at the Cape of Good Hope, or in any

* Latin, *æquus*, equal, and *nox*, night.

southern part of the world, are having short days and long nights. And this is in fact the case. It is when the earth is at this part of its orbit that we have our summer.

Now let us turn to the opposite position. We see at once that when the earth comes in its orbit to the point D, all these conditions are reversed; that the north pole is now turned away from the sun, and is revolving day and night in darkness, while the southern half of the globe rejoices in an ample measure of bright sunshine.

Thus we see how it is that the inclined position of the earth's axis explains **the length of our summer days** and of **our winter nights.**

When the earth in its course along its orbit reaches either of the points marked B, D there is a period of a few days, during which the length of the day scarcely appears to alter at all. Thus on the 19th, 20th, and 21st of June the sun rises at 3.44 and sets at 8.18 (omitting seconds), giving the same length for each day, and the difference of the length of day between the 19th and 21st of December is similar. So slight are the changes in the length of the day that it seems as if the earth stood still at these times. Of course this is not the case, but the slightness of the change has led to these periods being described as the times of the *solstices,* or standing still of the sun in its apparent upward or downward movements.

When the earth is at the point B, we say it is in its **northern summer solstice.*** When it is in the opposite position it is in its **northern winter solstice.** It will easily be seen, if we look carefully at the picture, that the time of the northern summer solstice is the time of the winter solstice in the southern hemisphere; and that, on the contrary, when the

* Latin, *sol,* sun, *sto,* I stand. The name was given at a time when it was believed that the sun moved round the earth, and is still used, although we now know that the earth revolves round the sun.

northern hemisphere is in its winter solstice, the southern is in the period of the summer solstice.

Summer Heat and Winter Cold.

Now we must go a step farther and see why it is that we have our summer hot and our winter cold, and why

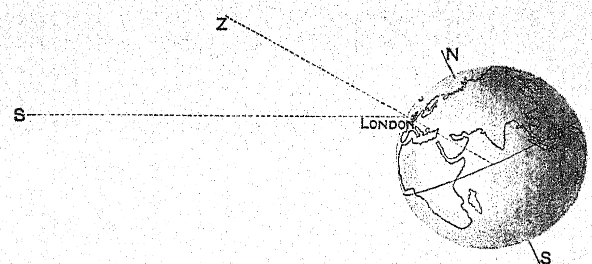

Fig. 9.—Diagram showing Position of the Earth in its Northern Summer Solstice.

it is that the farther we get from the equator the colder it becomes.

The Declination of the Sun.

There is another cause which helps to bring about the changes which we know as the seasons. We must all have observed that at different times of the year the sun rises to a different height above the horizon. In winter, not only does the sun rise late and set early, but the journey it makes in the heavens is a very short one. Even in the middle of the day it looks low down, and casts a long shadow.

In summer, on the other hand, the sun appears early in the morning, and by mid-day has risen high in the heavens,

so high that in the middle of June it seems *nearly over our heads.*

What is the reason of this difference in the position of the sun in winter and summer. We shall understand this if we look at Figs. 9 and 10. Fig. 9 shows the earth at a

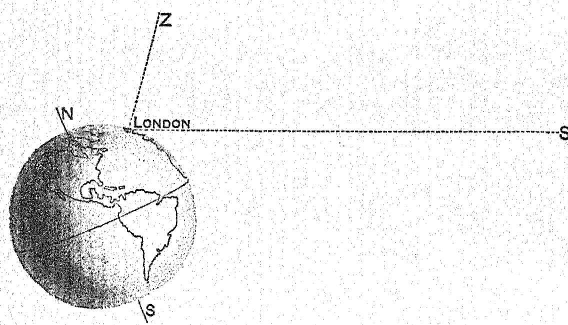

Fig. 10.—Diagram showing Position of the Earth in its Northern Winter Solstice.

time when the northern hemisphere is in midsummer, that is to say, inclined towards the sun during the daytime.

Midsummer Sun in London.

We see London,* which is much farther from the equator than from the north pole, in the position at which it has arrived by 12 o'clock in the day The sun, it is true, does not appear exactly over the observer, but if he were to point a telescope straight up to the point z over his head, he would only have to bring it down a little in order to fix it on the sun. The point exactly overhead in any place is called the **Zenith.** [2]

* Lat 51° 32'.

The Midwinter Sun in London.

Now look at Fig. 10, where the earth is shown at a time when the northern hemisphere is in midwinter. Mark the position of London, and see how far the line drawn to the **zenith** is from the *line to the sun*. At midday, when the sun is at its highest point, it will only appear a very little way above the horizon. In the summer, therefore, the sun's rays will not only fall upon London during the long summer's day, but they will fall upon it very nearly full, or *perpendicularly*. In winter, on the other hand, the day is short, and the sun's rays will strike London in a very slanting direction, or, as it is called, *obliquely*.

It is a fact which has been often proved, that the effect of rays of heat are greatest when they strike any object directly at right angles, and that the more oblique or slanting they are, the less heat will they produce.

It is not, however, hard to understand this.

Let us imagine that A be heat striking on a portion of the earth's surface, B C, a mile long. The full heat of the rays will then be felt upon the whole of the surface upon which it falls. But if we imagine the rays striking the earth in a slanting direction, it is plain that the portion of the heat which reaches each part of the surface is very much less than it was in the former case.

How great is the difference between the heat from perpendicular rays and that from rays which come in a slanting or oblique direction may be learnt from Fig. 11. A there represents a beam from the sun as it strikes the equator when the sun is straight above it. D represents a beam striking the earth at the same time close to the pole.*

* For a further explanation of this point see the chapter on Climate, p. 144.

It will be seen at once that, though the beams A and D are the same width, owing to the way in which the beam D is inclined, the space B E, upon which it falls, is very much wider than the space B C, upon which the perpendicular beam A falls. In other words, the full power of the heat in A is concentrated upon a very small space, and the effect upon that space is therefore very great. The heat of the beam D is spread out over the whole space B E, and its effect therefore is much less than that of A, and much less heat is brought by it to any part of the space B E. So great is the difference between the heat brought by a perpendicular beam and a slanting beam, that the heat brought by a perpendicular beam falling on the equator is 180 times as great as that brought by an oblique beam near the pole.

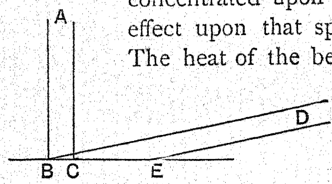

Fig. 11.—Oblique and Perpendicular Rays.

Here then we have a double reason why the seasons should differ from one another. In winter the sun's rays are much inclined, and they strike the earth for a short time only. In summer the rays fall more perpendicularly, and the sun shines for many hours.

It is important to understand and remember what has just been said about the difference in the height to which the sun rises at different times of the year.

The Effect of Declination.

If the earth stood exactly upright, as it turned round every part of the equator would pass exactly under the sun, and anyone standing on the equator would see the sun in the zenith—that is to say, exactly over his head—at noon every day. But, as we have already learnt, the earth does not stand straight up, but is inclined

or slanted at an angle of $66\frac{1}{2}°$ to its orbit. Fig. 12 shows the position of the earth when it is midsummer in the northern hemisphere, and it is plain that anyone standing on the equator at midday will see the sun not exactly over his head, but to the north of him at S. On the other hand, Fig. 13 shows us that in winter anyone standing on the equator at noon must look towards the south to see the sun. In both drawings the line A O A represents the line of the horizon, and it will be seen that

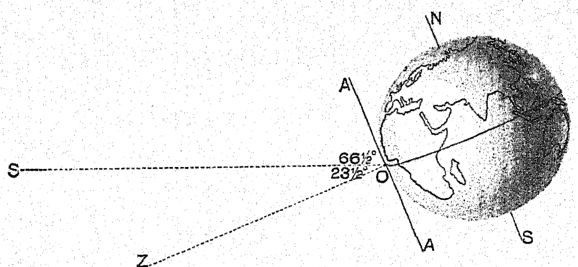

Fig. 12.—Diagram illustrating the Declination of the Sun.

the zenith line O Z makes an angle of 90 degrees with this line; but in Fig. 12 the angle A O S is less than the angle A O Z, and if we come to measure it we shall find that, instead of being an angle of 90 degrees, it is an angle of $66\frac{1}{2}$ degrees—in other words, that the angle S O Z is an angle of $23\frac{1}{2}$ degrees. From this we learn that the sun at midsummer in the northern hemisphere is $23\frac{1}{2}$ degrees north of the equator. Now if we turn to Fig. 13 we shall see in the same way that the angle Z O S is also $23\frac{1}{2}$ degrees—in other words, that in midwinter, in the southern hemisphere, the sun is $23\frac{1}{2}$ degrees south of the equator. This difference between the position of the sun and the equator is known as the *declination* of the sun, and the sun is

spoken of as being in $23\frac{1}{2}$ degrees north or south declination as the case may be.

Summer.

In Fig. 14 we have a representation of the earth in its **northern summer solstice**, and the rays of light and heat from the sun are shown by the dotted lines.

It will be seen at once that the sun's rays will strike

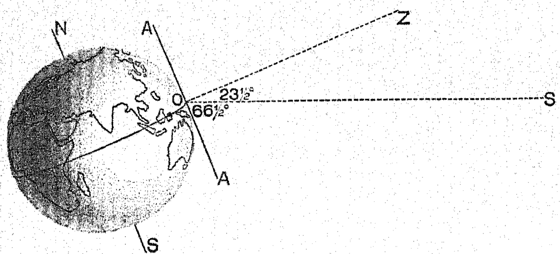

Fig. 13.—Diagram illustrating the Declination of the Sun.

at right angles at the point O; that is to say, anyone at that point will find the sun perpendicular above his head.

As we get north, it is true that the rays of the sun will strike the earth at a small angle, but still there will be a great amount of heat produced; whereas, on the other hand, directly we begin to get south of O the rays will begin to fall in a slant upon the earth, until by the time we reach the point marked A upon the figure, the rays will just graze the surface of the earth, and a person walking upon its surface at that point would see the sun lying flat upon the horizon to the north of him. A little farther south, and the sun would vanish altogether behind the edge of the earth, and there would be night.[3]

Winter.

Once more, the same effect is reversed when we come to look at the earth in its other position. Fig. 15 gives the position of the earth in its **northern winter solstice.** Here it is the south which gets the direct rays of the sun, and the north which gets the slanting rays; the south has its summer, and the north its winter.

Every day of the year, as the seasons alter, the declination of the sun alters too, and as we shall see farther on, it

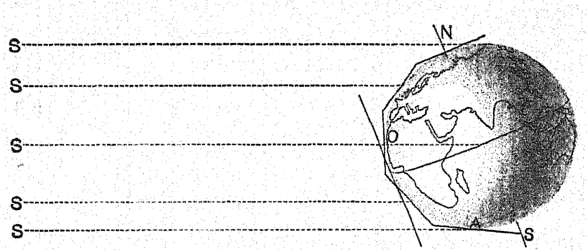

Fig. 14.—Diagram illustrating Incidence of the Sun's Rays (Summer)

is most important to bear in mind this declination, and to know exactly how much it is on any day of the year, before we make any calculations from the position of the sun.

Examples Near Home.

We do not require to be told that these laws which regulate summer and winter, night and day, heat and cold, may be studied in our own country. All of us have noticed the waxing and waning of the seasons, the shortening and lengthening of the days, the change of temperature between winter and summer.

Our little island lies at a point more than half-way from

the equator to the north pole. On Midsummer Day the earth is lying with its north pole pointing in the direction of the sun, and with a large portion of its northern half lit up by the sun's rays. At **forty-four minutes past three o'clock** in the morning the sun rises over England—that is to say, the revolving earth brings England out of darkness into the bright space illuminated by the sun. For sixteen and a half hours England remains within the light, and

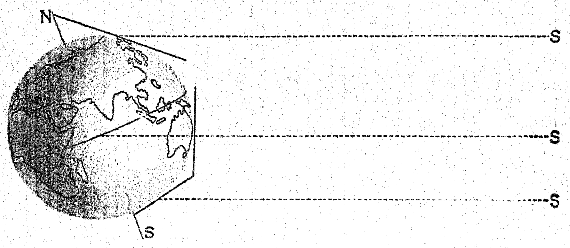

Fig. 15.—Diagram illustrating Incidence of Sun's Rays (Winter).

does not turn again into the darkness, away from the sun, until **eighteen minutes past eight.**

The rays of the summer sun at midday beat down fiercely upon our heads, and, as we know, the rays are nearly vertical, for the shadows are short, the trees cast only a ring of shade around them, and as we walk we can all but outstep our own shadows. Meanwhile in Melbourne and Sydney, our friends are wearing their warmest clothes, are keeping up their fires, and are doing all they can to get throught the wintry month of June with the least discomfort.

Six months later all is changed. The earth is at the other end of its orbit; the north pole points away from the sun. At **six minutes past eight o'clock** the sun has not well risen. At **fifty-one minutes past three o'clock** it has

set. At midday the slanting rays throw our long shadows before us on the frozen ground, and while we get out our skates and pile up the coals, our countrymen in Melbourne are celebrating their Christmas by a picnic on the Yarra Yarra River, and are doing their best in their thinnest clothes and with their shadiest umbrellas to keep off the overpowering sun.

The Length of the Day in England.

We have seen that the length of day varies in different parts of the world according to the time of year. The fact is one which we can easily observe within the limits of our own country. Any Londoner who happens to take his summer holiday in Westmorland or Northumberland will find when he has reached **Ambleside** or **Newcastle** that the evening light will linger on much later than it did when he left London, and that up to ten o'clock, or even past that hour, there will be daylight out of doors. And if we go farther and visit the northern point of Scotland, more than 500 miles north of London, we shall find that though we have not actually reached the region of perpetual daylight, into which we should come still farther north, we have nevertheless come to a point at which the night is only three or four hours long, and at which even during the few hours when the sun is hidden from view, the glow of his rays can be seen passing round from the north-west to the north-east, making a bright patch upon the sky. And of course, what is true in summer is true in the contrary sense in winter. In winter those who live in the far north, in Scotland or in Westmorland, will see the sun rise late in the morning and set early in the afternoon; their days will be shorter and their nights will be longer than those of the dwellers in the south of England.

Thus we see how in our own island we may study the lessons which we have learnt in this chapter.

Summary.

1. The inclination of the earth's axis to its orbit has very important results, and accounts in great part for the seasons of the year.

2. The length of the days and nights varies throughout the year. The days are shortest in winter and longest in summer.

3. The period when the days and nights are of equal length is called the equinox.

4. Owing to the inclination of the earth's axis the poles have continuous night in winter and continuous day in summer.

5. The periods when the sun appears to be highest or lowest in the sky are called the solstices.

6. Perpendicular rays produce greater warmth than slanting rays, hence, that part of the earth on which the perpendicular rays of the sun fall is the hottest.

7. Owing to the change in the declination of the sun, the summer rays are more nearly perpendicular than the winter rays.

8. Summer in the northern hemisphere corresponds with winter in the southern hemisphere, and *vice versâ*.

9. Examples of the facts in this chapter may be observed in England.

Explanation of Terms.

Equinox.—The time at which the earth in its orbit reaches a point at which the days and nights are of equal length. The spring equinox occurs about March 20, the autumn equinox about September 23.

SOLSTICE.—The time at which the sun is at the greatest distance north or south from the equator, so called because at such times (midsummer and mid-winter) the sun appears to stand still.

HORIZON.—The apparent junction of the earth and sky—the limit of sight.

ZENITH.—The point of the heavens exactly over our heads on any part of the earth's surface.

VERTICAL.—A perpendicular line passing through the zenith.

DECLINATION (of the sun).—The distance of the sun to the north or south in degrees from the earth's equator.

CHAPTER IV.

METHOD OF MEASURING LONG DISTANCES BY TRIANGULATION. [4]

The Size of the Earth.

In the last chapter we spoke about the position and movement of the earth, and the effect which they have upon our daily lives. We have seen how day and night, summer and winter, heat and cold are accounted for.

We now come to another question, namely, what is the **size of the earth** upon which we live, and how do we measure it? We already know that the earth is a globe and that it revolves on an axis inclined to the direction in which it is moving. We now have to find out what is the size of this globe, how far it is round the equator, how far from pole to pole. In order to discover the answer to this fresh set of questions it is necessary to understand a little *geometry* (*see* pp. 3 and 4).

How to Measure It.

It is perfectly plain that we cannot take a measuring tape and walk round the earth, laying down our tape as we go, but though we cannot measure the whole earth with a tape, we can measure a small portion of it, and can measure it very exactly indeed, and it is by such a small, but exact,

measurement that step by step we are enabled to measure the size of the entire earth.

As we all know, it is customary in England to take our measurements in feet, yards, and miles, and a very inconvenient and old-fashioned plan it is. But geographers, as a rule, use for the purposes of measurement a mile which is not exactly the same as our mile. Our mile contains 1,760 yards; the mile generally used by geographers, and which is known as the **geographical mile**, contains 2,027½ yards.

It is this measurement which is used at sea, and which equals the **knot** by which we describe the rate of sailing of ships at sea.

As a first step towards measuring the surface of the earth, it is necessary to measure with great accuracy on some part of its surface a short distance—for instance, a single mile. In several parts of the earth this has been actually done, and two marks have been put up, which by measurement have been found to be exactly a mile apart. Here is one of the necessary steps which must be taken in order to find out the size of the earth, and now we come to the point at which we must begin to get help from the science of geometry.

Triangles and their Uses.

A **triangle** is a three-sided figure. Whenever we know the length of one side of a triangle, and know the angles at the ends of that side, we can find out the length of the other two sides, and we can tell the size of the third angle. It is usual to speak of the side of the triangle which we know as the **base**, and put shortly, the matter may be stated thus—*where the length of the base of the triangle and the angles at the base are known the length of the sides and the remaining angle will also be known.* This is the geometrical truth which lies at the bottom of all measurements

which we cannot make with an actual tape or by other simple means of the kind. The whole measurement of the earth, and indeed of the sky, is done by what is known as the method of triangulation, or the use of triangles.

Let us see what this means.

Look at Fig. 16; in the distance there is a church spire. We want to know how far off it is.

What do we do?

First of all we get our **base**. This is done by taking any two points near where we stand. The points in this case are the posts marked *a* and *b*. We measure the distance between them, and we find it is 100 yards; *a b* is then the base of our triangle. We go to *a* and look at the church spire from that point. We find that the line along which we look, marked in the picture as the line *a c*, forms an angle with the base *a b*. By the use of a small telescope called a *theodolite* we can find out exactly what that angle is. It turns out to be an angle of 87° 8′. We then go to *b*. The church which just now stood upon our right-hand side now appears on our left, and looking at it in the same way we find that the line shown as *b c* makes an angle with the line *a b* of 87° 8′. The triangle is therefore isosceles, that is, two of its sides are equal. Now we have got a triangle *a b c*, of which we know the length of the base *a*, and the size of the two angles at the base *c a b* and *c b a*. [5]

When we have learnt this much, we can tell at once what is the length of the other two sides *c a* and *c b*, and what is the size of the angle *a c b*. There are several ways in which this can be done. There is one very simple one, which consists in making a drawing representing the triangle, of which we have obtained particulars. The drawing will be, of course, very much smaller than the triangle made by the base *a b* joining the two posts, and the dotted lines passing over the surface of the country; but if

we make each part bear *the same proportion* to the other as it did in the larger triangle, it will only require a simple calculation to give us the information we want.

If, instead of a base line 100 yards long we take a base line one inch long, we shall then have reduced all the measurements by $\frac{1}{3600}$th part. Now if at the end of our new base we make two angles equal to the two angles we before measured, and continue the sides of the triangle until they meet at the point *c*, we shall have an exact picture or representation of the large triangle, only *3,600 times smaller*, and this small triangle we can easily measure with ruler or tape, and can tell to a small fraction of an inch the length of the two sides *c a* and *c b*. We find that they are respectively 10 inches and 10 inches.

What does this tell us?

It tells us that the sides of the larger triangle, of which the smaller one is a picture, are respectively 3,600 times 10 inches and 3,600 times 10 inches, that is to say, 1,000 yards and 1,000 yards, and thus without going over the distance between our base and the church tower, we have made an actual measurement of the distance between them.

How Long Distances can be Measured by Triangles.

Now that we understand how by the use of triangles the measurement of great distances can be made we shall be able to go farther, and to see how geographers set to work to measure the surface of the earth.

We saw that the first thing to be done in measuring a long distance by the aid of a triangle was to get a **base line** of which we knew the exact length. In the illustration given the base line was a very short one, only 100 yards. If instead of a base line 100 yards only, we had one of 1,000 yards, we could use that to measure to some still more distant point than the church. Can we get such a base

line? Certainly we can. Not only can we get it, but we have already got it. The very purpose for which we made our triangle was to find out the distance between the point *a* and the church. Now we have found it out, and we know it to be 1,000 yards. In other words, here is exactly what we want, a base much longer than that which we used in the first instance, and of which we know the length. All

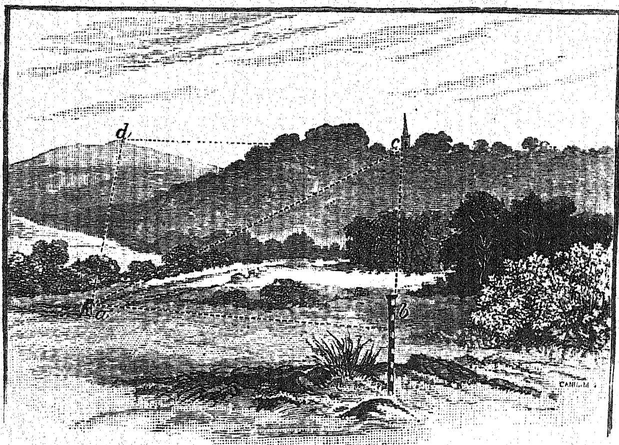

Fig. 16.—Measurement by Triangulation.

that now remains to be done is to use the new base *a c* in the same way that we used the old base *a b*. This time we shall measure the distance of some object much farther off than the church was from *a b*.

Triangulation.

Let us take the top of a distant mountain. We set to work as before. From one end of the base, that is at *a*, we look through our theodolite at the mountain top, and we find out what is the angle between the line

joining *a* and *d* (the mountain) with the line of the base *a c*. In the same way at *c* at the other end of the base we make a similar observation; and now once more we have a triangle *a d c*, of which we know the length of the base, and the two angles at the base. Once more also we shall be able to calculate what is the length of the other two sides, *a d* and *c d*, in other words to tell the distance from *a* to *d*

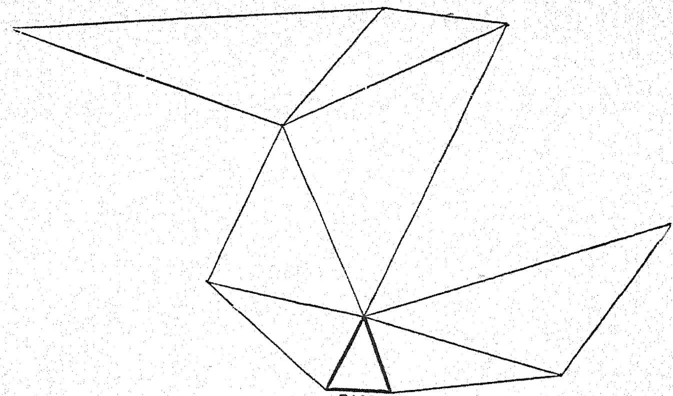

Fig. 17.—Diagram of Triangular Survey.

and from *c* to *d*. Let us suppose that it turns out to be **ten miles.** Then, of course, we can begin the same plan over again; only this time we shall have got a still longer base to start from, for we shall use the line *a d*, which we know to be ten miles long, for the purpose. And so it is possible to go on increasing the length of our measurements as long as we can see the object whose distance from us we want to measure.

Measurement of the United Kingdom.

And this is, in fact, the way in which measurements of the earth's surface are taken; and it is by this method of **triangulation** that the whole of the United Kingdom has

been measured with great accuracy. Seven different bases were chosen in different parts of the country, and were measured with the greatest possible care, and these were made the starting-points for a number of triangles drawn in the way that has been described (Fig. 17). It is most important in making large measurements by the aid of triangles that the base line should be measured with the greatest possible accuracy, and that no mistake, however slight, should be made in taking the angles. An angle of one degree is so small that it is scarcely possible to draw it upon this page, but an error of one degree in taking the angle required for measuring a long distance would be considered a very serious error indeed. We shall easily understand the reason of this, for though the distance between the two lines which join each other at an angle of one degree only is very small at first, the farther the lines are continued the greater it becomes, until at a distance of 100 miles *the error will be more than a mile and a half.*

The Ordnance Survey.

Throughout the whole of the United Kingdom the work of measurement by triangles has been carried out by a staff of skilled persons, who form what is known as the **Ordnance Survey Department.**

In measuring the United Kingdom about 250 triangles were used; the length of the sides of these triangles varies from ten miles to as much as 111 miles. The sides of this last great triangle were drawn from three points in England, Ireland, and Wales respectively. The observers, standing on **Scawfell Pike** (3,161 feet), in Cumberland, waited many weeks for a day fine enough to allow them to see at the same time the mountains of North Wales and the mountains of Down in the north of Ireland. At last, after many disappointments, the fine day came, and the observers were

able to see at the same moment the top of **Snowdon** (3,511 feet), and the top of **Slievedonard** (2,796 feet), in the Mourne Mountains. They were thus enabled to find out what was the angle between the line joining **Snowdon** and **Scawfell** and the line joining **Slievedonard** and **Scawfell.** Almost all civilised countries have now been carefully measured or surveyed by this method of triangles, which is usually known as a trigonometrical survey. One of the most remarkable of such surveys is that by means of which British officers have measured the vast continent of India.

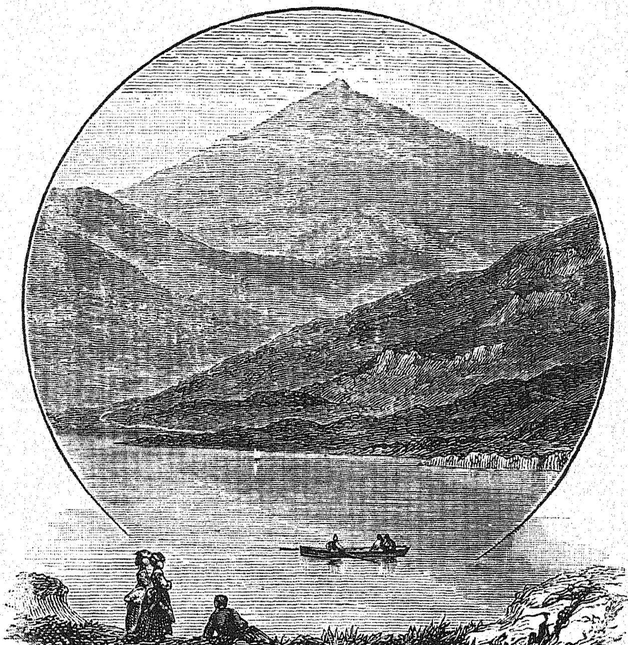

Fig. 18.—View of Snowdon.

If we have understood this chapter, we shall see clearly how it is that distances on the earth's surface may be measured, and we shall therefore have come one step nearer to answering the question of how the entire surface of the earth can be measured.

SUMMARY.

1. Very long distances on the earth's surface are measured by triangulation.

2. If two sides and one angle of a triangle be known, the length of the third side and the remaining two angles can be found.

3. The United Kingdom has been measured by the use of triangles.

4. The work has been done by the Ordnance Survey.

5. The measurement of long distances by triangulation is a step towards the measurement of the entire surface of the globe.

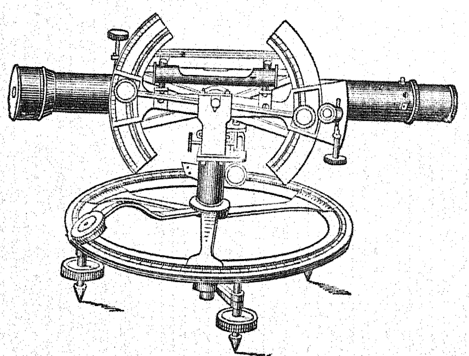

Fig. 19.—A Theodolite.

CHAPTER V.

MEASUREMENT OF THE EARTH.

The Circumference of the Earth.

LET us see what are the steps by which we can get to know the size of the earth.

First of all, let us imagine that *o o* (Fig. 20) is a circle representing the outline or circumference of the globe. As a matter of fact, the figure ought not to be quite round, but as we have seen (Chapter II.) should, in order to represent the earth's shape quite correctly, be slightly flattened at the top and bottom and bulged outwards in the middle. But for the present purpose we will take the perfect circle to represent the outline of the earth. It is usual in measuring a circle to divide it into 360 equal parts, called **arcs of degrees**, or briefly, degrees.[6] There is no particular reason beyond that of convenience why this number of divisions should be taken; we might divide the circle into 100 or 400 parts instead of 360, and indeed, this is sometimes done. But as a matter of actual practice, it is usual, as we have said, to divide the circle into 360 degrees. Each degree is again divided into 60 **minutes**, and each minute into 60 **seconds**. Thus the complete circle

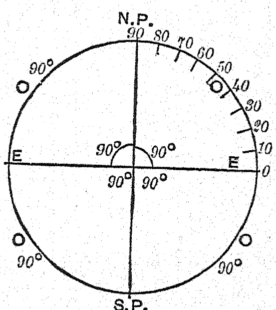

Fig. 20.

contains 1,296,000 seconds. If now we draw two lines through the centre of the circle representing the earth, the two lines being at right angles to each other, we shall divide the circle into four equal parts, each of which will contain one-fourth of 360 degrees or 90 degrees. If *n p* be taken as the north pole and *e* as the equator, the distance between the north pole and the equator is plainly one-fourth of the whole circle of the earth, or 90 degrees.

Can we Measure a Degree.

If only we knew the length of the arc of one degree we could, of course, easily find out the length of the arc of 90 degrees. And when we knew the length of the arc of 90 degrees we should only have to multiply the figure by four to find out the length of the whole circle or circumference of the earth. And this, too, would tell us the **diameter** of the earth; that is to say, the longest distance through it in a straight line from side to side or from pole to pole. For it is a fact well known to mathematicians that *the circumference of a circle is rather more than three times its diameter.* All this we could find out if once we knew the length of a single degree. The question is, *Can we in fact measure a degree?* and if so, how?

We have already seen that it *is* possible by the use of triangles (Chap. IV.) to measure long distances with very great accuracy, and so one part of the difficulty can certainly be got over. If we know where the degree begins and ends there will be no difficulty in measuring it, and finding out how many miles of the earth's surface it contains. But, unfortunately, the degrees are not marked like mile-stones upon the surface of the earth. If we were to start from the equator in the direction of the pole, there would be nothing on the surface to tell us when we had gone **one-ninetieth**

part of the distance; in other words, when we had passed over one degree.

How to Measure a Degree.

There is, however, a way by which we can discover not only how many of the 90 degrees we have gone over, but also at what particular point between the equator and the pole we stand at any given moment.

If there be such a method as this, it is plain that it will help us out of our difficulties, and will enable us to do what we wanted, namely, to measure the length of a degree. For let us suppose that by our plan we find out that we are *one-third of the distance from the equator to the pole*, we shall know that we are 30 degrees, or one-third of 90, from the one, and 60 degrees, or two-thirds of 90, from the other.

And now suppose that we move still farther towards the pole, and once more making use of our method, find out that we are $\frac{31}{90}$ instead of $\frac{30}{90}$, or one-third of the distance from the equator to the pole. We shall see in a moment that the distance we have gone over is *one-ninetieth* of the distance between the equator and the pole—in other words, it is exactly the degree which we wanted to find.

As soon as we know where our degree begins and ends, we can set to work with our triangles and measure it.

Now let us see what is the plan by which we can secure this result, and thus take our first step towards the measurement of the earth.

An Observation from the South Foreland.

We learnt in Chapter III. (p. 21) that at the time of the equinox the sun stands exactly over a certain spot on the equator. Now suppose that the sun, as seen from the coast of Kent at noon on the 20th March,* appears at an angle of 38° 51′

* The vernal or spring equinox. [7]

above the horizon, we have only to subtract 38° 51′ from 90° to discover that the angle between the line A S which is drawn from the top of the lighthouse to the sun and the line A Z drawn from the top of the lighthouse to the zenith is 51° 9′ (Fig. 21). When we know this we know also that the lighthouse stands at a point just over $\frac{51}{90}$ths of the distance from the equator to the pole. [8] If by such an observation as that which has just been described it be possible to find out that the South Foreland is 51° 9′ from the equator, it will be possible, by repeating the experiment in other places, to find out some spot which is 52° 9′ north of the equator, or exactly one degree north of the Foreland. As a matter of fact, we should find that there was such a spot a few miles north of the town of Orford in Suffolk, which is exactly one degree north of the Foreland.

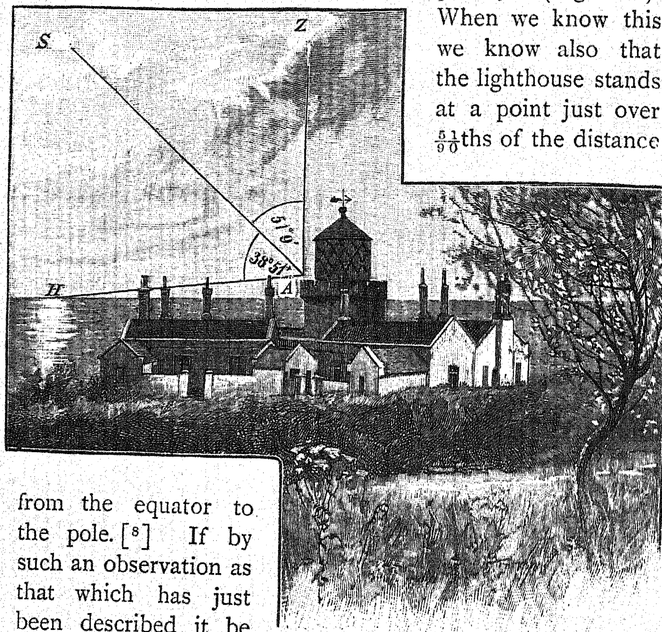

Fig. 21.—An Observation from the South Foreland

A Short Step and a Long One.

Here, then, we have what we were looking for, namely, two points on the earth's surface separated from one another by exactly one degree. We cannot measure the whole earth, but by triangulation we can measure the length of one degree. Let us suppose, for instance, that a *base line* a mile long be measured from the Foreland to any fixed point near it. From this base line a triangle is taken whose sides are 12 miles and 14 miles respectively, and whose base is the measured base a mile long. From one of the sides of this triangle another and larger triangle is drawn. And thus, by the use of our system of triangulation, following the plan described in Chapter IV., the exact distance between the South Foreland and Orford can be measured.

The Measurement of the Globe's Circumference.

When the measurement is complete we shall see that we are now in a position to find out the measurement of the whole globe. To understand this we must call in the aid of a little arithmetic. The distance between the Foreland and Orford, in other words, the length of the degree, will be found to be nearly 69 miles. But we already know that between the equator and the pole there are 90 degrees; 69 × 90 equals 6,210: there are, therefore, 6,210 miles between the equator and the pole. If the distance from the equator to the north pole be 6,210 miles, the distance from the equator to the south pole will likewise be 6,210 miles; 6,210, plus 6,210, equals 12,420. Now we are half round the globe—double the distance, and we shall have the distance all the way round, viz., 24,840—in other words, the **circumference** of the globe.

Diameter.

But this is not all that we have learnt. If we are mathematicians we know, and if we are not, we

must believe mathematicians who tell us, that the **circumference** of a circle is nearly 3·1415 times the **diameter.** For instance, if we measure a halfpenny, which is exactly an inch across its centre, we shall find that its circumference is 3·1415 inches. The diameter of the circle round the globe which we have measured is a line drawn through the globe from the north to the south pole, and the length of this line will be found to be 7,899 miles. It is called the **Polar Diameter** of the earth. The circumference of the globe drawn round the two poles is 24,840 miles, as we have just discovered in another way.

It should be noticed, however, that we have only spoken hitherto of the **Polar Diameter**, and of the circumference drawn one way. We have said nothing about the diameter through the equator, known as the **Equatorial Diameter,** or of the circumference drawn round the equator. It would seem at first sight that if we know one diameter or one circumference we must of necessity know the other; and if the globe were perfectly round, or, to speak more correctly, if it were a **true sphere,** its diameter would be the same in all parts, and its circumference would be the same in all parts. But, as we saw in Chapter II., the world is not a true sphere; on the contrary, it is an "**oblate spheroid,**" a figure, that is, which is flattened down at top and bottom as shown in Fig. 1. The result of this is that the length of the arc of a degree increases as we approach the poles or flatter parts of the earth, and decreases as we approach the equator. If we understand this it will not be hard to understand also that a line drawn round the earth through the two poles will be a little shorter than a line drawn round the earth following the direction of the equator. The difference has been calculated, and it has been found that while the distance through the earth from pole to pole, called the **Polar Diameter,** is 7,899

miles, the distance through the globe at the equator, called the **Equatorial Diameter,** is 7,926 miles, or 27 miles longer than the **Polar Diameter.**

SUMMARY.

1. The surface of the earth is divided into arcs of degrees, minutes, and seconds. [6]

2. A degree is a division of a circle. There are 360 degrees in a circle.

3. The length of the arc of a single degree can be measured.

4. This measurement is made by triangulation.

5. When we know the length of a degree we can find out—

   (*a*) The circumference of the globe.

   (*b*) The diameter.

6. In calculating the diameters and circumference of the globe, we must take into account the fact that it is not an exact sphere, but an oblate spheroid.

7. Thus we find the polar diameter of the earth is less than the equatorial diameter.

EXPLANATION OF TERMS.

CIRCUMFERENCE.—The line that bounds a circle.

DIAMETER (the earth's).—The line passing through the centre of the earth, terminated at each end by the circumference.

EQUATORIAL DIAMETER.—The diameter of the earth measured at or across the equator.

POLAR DIAMETER.—The diameter of the earth measured from pole to pole.

CHAPTER VI.

LATITUDE AND LONGITUDE.

Geographers have agreed to divide the surface of the globe into a number of different spaces by imaginary lines known as the **lines of latitude and longitude.** The lines, or, as they are properly called, **parallels of latitude,** are drawn round the earth in the direction shown in Fig. 22. They begin on each side of the imaginary line called the **equator,** which has been already referred to in an earlier chapter. It will be seen from the figure that the equator forms a circle round the globe exactly at the middle, and is at an equal distance from the two poles.

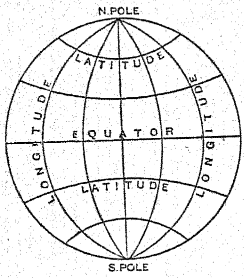

Fig. 22.

Latitude.

Between the equator and the pole there are usually drawn on maps 90 parallels of latitude, and the distance between any two parallels is **one degree,** which, as we have already seen, is a distance of nearly 69 miles.*

The parallels are numbered north and south from the equator (which is marked 0), beginning at 1 and ending at 90; latitude 1° north is one degree or 69 miles north of the equator; latitude 1° south is one degree or 69 miles south of it.

* Geographers usually reckon distance by geographical miles, of which there are 60 to a degree; 60 geographical miles equal 69·15 English or statute miles.

Longitude.

The lines, or, as they are called, the **meridians of longitude**, are drawn round the globe from top to bottom, that is from pole to pole, as shown in the drawing. If 360 meridian lines are drawn, the distance between any two of them at the equator is $\frac{1}{360}$th part of the circumference of the earth at that point, and measures, like the *degree* of latitude, nearly 69 miles.

It will be seen that as they draw nearer to the two poles, the meridians draw closer and closer together, and although the distance between them is always $\frac{1}{360}$th part of the circumference of the globe at any particular point, the actual distance between them in miles will get less and less as the lines approach the north or south pole. At length all the lines meet together or *converge* at the two poles, and the distance between them is reduced to nothing.

How to Reckon Latitude and Longitude.

In order to describe the position of any place upon the surface of the globe it is usual to make use of these parallels of latitude and meridians of longitude as guides. It is easy to know where to begin in counting the parallels of latitude, for it is natural to start either at the pole or the equator. We have seen that it is customary to start at the equator and count north and south from it. It is not quite so easy to fix a point from which to begin counting the meridians of longitude. There seems no particular reason why any one of them should be made the starting point. For convenience' sake, however, it is necessary to fix on one particular meridian, and to make it our starting point.

The Meridian of Greenwich.

English geographers have naturally enough chosen a meridian which passed through England, and as they wanted to give a name to the particular meridian from which

they chose to count, they fixed upon the name of an English town through which it passed. Our great English observatory, from which the movements of the sun, the moon, and the stars are watched, is situated at **Greenwich,** a town lying on the south side of the river Thames, 5 miles to the south-east of London. It was through this observatory that English observers drew their meridian line, and thus it comes about that all Englishmen throughout the world begin to count their lines of longitude from the **meridian of Greenwich.** In any English map you will see that the line which passes through Greenwich is marked 0°, and that the meridians are numbered to the right and left from longitude 0° up to longitude 180° each way; until exactly opposite Greenwich, on the other side of the world, we come to a point through which passes a meridian which is the 180th to the west of Greenwich, and also the 180th to the east. In this way the whole number of 360 degrees of longitude is made up.

Longitude 0° 0′.

Anyone who is curious to know what it is like to be in longitude nothing should go down the Thames by steamer, and as he passes opposite the Royal Observatory at Greenwich he will see painted up on the wall longitude 0° 0′.

But the very reason which has made English people take Greenwich as a place to count from was pretty certain to make many who were not Englishmen count from some other town as their "meridian."

We took the meridian of Greenwich because at Greenwich was our great English observatory. In the same way the French and the Germans and other nations chose places in France, in Germany, or in some other country, through which to draw their respective meridians.

Foreign Meridians.

And thus it happened that in the maps of different countries the numbers of the lines of longitude were not the

same; the French counted from **Paris**, the Germans from **Berlin**, the Russians from **Pultowa**, the Spaniards from **Ferro**, in the Canary Islands.

Naturally this plan led to much confusion. As time went on, and the people of different countries began to travel more, to see more of other lands than their own, and to make use of maps drawn by foreigners, the inconvenience of having several "meridian" points began to be felt. A remedy of some kind was required. The most natural way of setting things right was to choose one starting point as a meridian and to use it in all maps for the future. But here, of course, a difficulty arose as to which point should be selected for the purpose, and which country should keep its own meridian.

At last it was proposed to settle the matter by agreement between the different countries, and in the year 1884 a conference met at Washington, at which all the important nations of the world were represented. It soon became clear that the simplest plan would be to choose the particular meridian the selection of which would give rise to the smallest alteration of the maps already in existence. It so happened that England being a country with many colonies, and Englishmen having spread more widely over the face of the earth than any other people, there were more English maps, and especially more English charts (that is, maps of the sea), than there were maps and charts of any other nation. And thus it came about that for the general convenience it was proposed that for the future the meridian of longitude to be used in all maps, whether English or not, should be the **meridian of Greenwich**; and that all map-makers should number their lines of longitude east and west from Greenwich.

Unluckily, it was found impossible to come to an agreement which would please everybody, and two of the countries whose representatives took part in the conference

refused to be bound by the wishes of the others. These were the representatives of France and Brazil. And hence it comes about that while in English, American, German, and many other maps we find one plan adopted, and the longitude always numbered from Greenwich, we still find the old plan adhered to in French and Brazilian maps, and the meridian of Paris (2° 20′ E.) used in one case, and that of Ferro in the other. [9]

We must remember, however, that *in this book longitude is always counted east or west from Greenwich.*

How to Use Latitude and Longitude.

Having got so far, and having learnt what is meant by a parallel of latitude and a meridian of longitude, we come next to the question of how to use these lines. How can we describe the position of a place by the use of latitude and longitude, and what is meant by saying that a place in London is *situated* in 51° 32′ *north latitude* and 0° 5′ *west longitude*, or that Bristol is in lat. 51° 28′ north, and long. 2° 25′ west?

The method of describing the name of a place by means of the lines of latitude and longitude is simple enough. Let us take the city of **Bristol.** We shall find on looking at the map that the meridian of longitude which is numbered 2, or the second meridian, passes to the right or east of Bristol, and that the parallel of latitude which is numbered 51, and which is therefore the fifty-first of the 90 parallels which are drawn between the equator and the north pole, passes just below or to the south of Bristol. If, therefore, we want to describe the position of Bristol and to know where to look for it upon the earth's surface, it will be enough to say that it is in longitude 2° east and latitude 51° north, and our attention will immediately be turned towards the space which is bounded on two sides by the meridian 2° and the line of latitude 51°.

It is necessary to say in this case *west* longitude and *north* latitude in order to make it clear that we are not speaking of a place to the east of the meridian of Greenwich or south of the equator; for, as has already been pointed out, in marking the lines of latitude and longitude geographers count both ways, east and west from Greenwich and north and south from the equator. Thus the first meridian of longitude on the west side of Greenwich is *longitude* 1° *west*, the first on the east side is *longitude* 1° *east;* and in the same way the first parallel of latitude north of the equator is latitude 1° north, while the first south of the equator is latitude 1° south.

Therefore it will be seen that if we omitted to say whether it were east or west longitude, or north or south latitude, we might make a very serious mistake. For instance, longitude 2° and latitude 51° might be east longitude and south latitude; in which case, instead of describing the position of Bristol, we should be describing a spot in the middle of the South Atlantic Ocean many hundreds of miles from any land.

An Observation of the Sun.

Let us suppose that at midday on the 20th of March* an observer were standing on the equator at the point marked E (Fig. 23). The sun will then be directly above his head, in the central point of the heavens. This point, as we learnt at page 25, is called the **Zenith.** A line drawn from the centre of the earth through the point E, on which the observer stands, would, if continued, reach the sun. But if we pass along the surface of the globe from E to F, and from that point look up in the zenith, that is to say, at the point directly above our heads, it is plain

* The vernal equinox, it must be remembered, is the period in spring when the sun is exactly over the equator (*see* p. 45 and note).

that we shall not see the sun there, but that we shall be looking in the direction of the dotted line F *f*, which is the continuation of the line which joins O and F. In order to see the sun from this point it will be necessary to turn our telescope or our eye until it is on the line F S, and if we look at the figure we shall see that we now have an angle *f* F S. It is by means of this angle that we get an answer

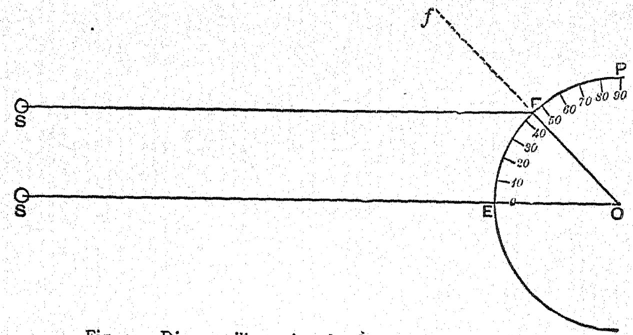

Fig. 23.—Diagram illustrating the Observation of Latitude.

to our question, and find out at what point of the earth's surface we stand, and how far we are from the equator, and how near to the pole. [3]

It is not difficult to understand this. We have already seen that the distance between E and P is divided into ninety equal divisions or degrees for convenience of measurement. It is plain therefore that by the time we have got half-way from E to P, we shall have got over half the number of divisions or degrees into which E P is divided, *namely, half* 90, *or* 45 *degrees.* At two-thirds of the distance we shall have passed through 60 *degrees;* at one third, 30 *degrees;* and so on.

A Lesson from the Barrack Yard.

Now let us take a simple example to show how we learn from the angle *f* F S how many of the 90 degrees we have passed over. A drill sergeant places a recruit in the proper

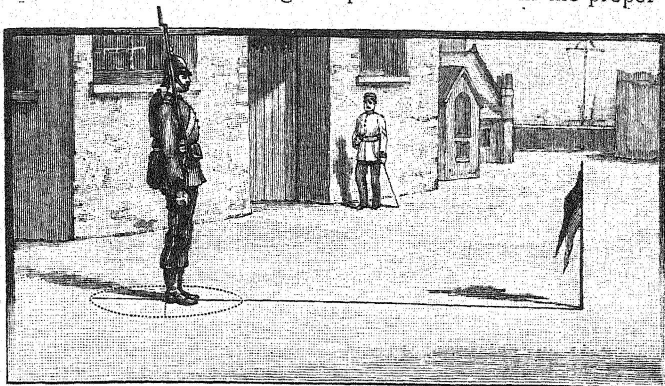

Fig. 24.—Illustration of Apparent Position of the Sun.

drill position, facing a flag in the barrack yard (Fig. 24). The position will then be that shown by the two feet at A in the diagram. The sergeant gives the word "**half left turn,**" and the recruit changes his position to that shown at B in the dia-

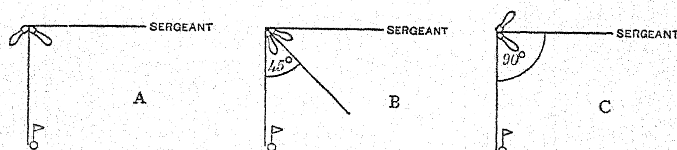

Diagram illustrating Fig. 24.

gram. The flag is now to the right of him, and he can only fix his eye upon it by turning his head to the right just as far as he has already turned his body to the left. How far has he turned? He has turned through the eighth part of a circle, which, as we already know, contains **45 degrees.** He must

therefore turn his head round 45 degrees to the right to correct the change in the position of his body.

In the same way, if the sergeant give the word "**left turn**," the recruit will turn round through **90 degrees** or one-quarter of a circle, and his feet will be in the position shown at C in the diagram. In order to fix his eye upon the flag he must turn his head to the right through the same number of degrees that he has already turned his body to the left—that is to say, through 90 degrees—and he will now have to look straight over his right shoulder to see the flag. From these facts we can reason as follows :—If we know through what part of the circle the recruit has turned, we know also the size of the angle made between his first position and his second position. Thus, if he has turned through an eighth of the circle, the angle is an angle of 45 degrees; if through one-fourth, it is an angle of 90 degrees; and so on.

Now having got so far, it is possible to do the sum the other way, and to say that if we know the number of degrees in the angle between the first position and any other position, *we shall be able to tell through what portion of the circle the recruit has turned.* Thus, if we find that he has turned through 45 degrees—that is to say, that the angle between his first and second position is an angle of 45 degrees—then we shall know at once that he has turned through an eighth of a circle; if the angle be 90, through a quarter of a circle; or if it be 1 degree only, then that he has turned through $\frac{1}{360}$th part of the whole circle.

The Lesson Applied.

It is now time to go back to the earth, and see how far this example helps us to understand what we learnt just now, and how it is that we can find out by observation on what part of the earth's surface we stand. Let us turn back to Fig. 23, p. 56.

It is plain that an observer standing at the point E, and

looking at the sun, is in the same position as the recruit in the first position, and the sun exactly over his head in the zenith represents the flag.

In the same way the observer at F is in the same position as the recruit after he has got the order "half left turn." The angle between his first and second positions is the same as the angle *f* F S. Now it is possible by means of an instrument called a **sextant**, or by a telescope, to measure this angle, and we know already how such a measurement leads us to the answer to our problem.

Let us leave illustrations and come to an actual example on the earth's surface.

Let us suppose as before that one observer is standing at the point E on the equator at midday at the time of the equinox. By the aid of his sextant, or some other instrument, he will find out that the sun is exactly overhead or in the zenith, and that, therefore, the angle between the line joining the centre of the earth O and the zenith on the one hand, and the line joining the centre of the earth and the sun on the other, is nothing at all, for the lines lie one upon the top of the other, or, to use the proper word, *coincide*. There can be therefore no angle between them. From this he knows that he is standing exactly in the centre line of the earth 90 degrees from each pole.

On the same day another observer at Turin, in Northern Italy (45° 3′ N.), which is represented in the figure by the letter F, looks at the zenith, that is the point exactly above his head, and at the sun. He finds that instead of the two lines *coinciding* there will be an angle between them, which is the angle *f* F S in Fig. 23. He now knows that he is 45 degrees from the centre line of the earth, and 45 degrees from the pole—in other words, that *he is half-way between the equator and the pole*.

As a matter of actual practice it is not usual to take the line from the point on which the observer stands to the

zenith as one side of the angle to be used, for the simple reason that it is not always easy to find out exactly where the zenith or central point of the heavens is. But the same result is arrived at in another way. If we divide an angle of 90 degrees into any two parts, it is plain that if we know how many degrees there are in one part, we can also tell how many degrees there are in the other. So, for instance, if there be twelve apples in a dish, and we take away seven, we know that five remain.

Zenith and Horizon.

In the same way, if one of the two angles into which an angle of 90 degrees is divided be 75 degrees, the other must of course be 15 degrees, the number required to make up 90. If one angle be 60 the other must be 30, and so on. The second angle is called the *complement* of the first.

An Example at the Foreland.

If we stand at the foot of a lighthouse, such as that upon the South Foreland (Fig. 21), as the top of the lighthouse points straight to the zenith, or point above our head, we shall then find that the lighthouse stands up at right angles (90 degrees) to a line drawn from its foot to the **horizon** or point where the sea and sky appear to join.

If at twelve o'clock we turn towards the southern horizon, we shall see that a line drawn from the foot of the lighthouse to the sun will be between the line up the centre of the lighthouse itself and the line drawn from the foot of it to the horizon.

Now we have already seen that if we know the angle between the line drawn from the point at which we stand to the zenith, and the line joining the same point to the sun, we can tell on what part of the circle of the earth's surface we stand. But it is plain that the angle made by the line of the lighthouse and the line to the sun (Z A S), is only

part of the right angle contained between the line of the lighthouse and the line to the horizon (Z A H); and that the other part of it is the angle (S A H) between the line from the foot of the lighthouse to the sun, and the line from the foot of the lighthouse to the horizon; in other words, that the *one angle is the complement of the other.* But we have already seen that if we know the size of one of the angles into which a right angle or angle of 90 degrees is divided, we can tell the size of its *complementary* angle. If, therefore, instead of finding out the angle between the line to the zenith and the line to the sun, we find out the angle between *the line to the sun and the line to the horizon*, we shall be able to tell in a moment what the former angle is. [6]

Summary.

1. Geographers have divided the surface of the globe by lines of latitude and longitude.

2. The lines of longitude are called meridians, the lines of latitude are parallel to each other.

3. On English and most other maps the lines of longitude are counted east and west from the meridian of Greenwich.

4. All countries do not use the same meridians.

5. Lines of latitude and longitude are used for describing the position of places upon the earth's surface.

6. The longitude and latitude of any place are determined by observation of the sun or stars.

Explanation of Terms.

Meridian.—An imaginary line joining all places on the earth's surface where it is noon (midday) or midnight at the same time.

Meridian of Greenwich.—An imaginary line joining all places on the earth's surface where it is noon (midday) or midnight at the same moment that is noon and midnight respectively at Greenwich. [10]

CHAPTER VII.

THE USE OF LONGITUDE AND LATITUDE.

An Ocean Voyage.

Now that we have learnt what is meant by Longitude and Latitude it is easy enough to make a proper use of our map, and to find out whereabouts any particular place is situated directly we know its longitude and latitude. But there remains a problem which is not quite so simple, and that is to find out in what longitude and latitude we ourselves are at any place. It is simple enough to look at the map and say "Paris is in long. 2°20′ E., and lat. 48°50′ N., and when we say so to believe that the map is telling the truth. But how did those who made the map in the first place know what the facts were, and how did they find out the longitude and latitude of the places before writing them down? We shall soon see that anyone who wishes to be a geographer must learn how this was done. In the first place he ought to know how the maps he uses were made. In the second place he will find that it is often necessary to repeat the process by which the position of Paris or Timbuctoo, or any other places which are marked on the map, was originally found out.

When a traveller arrives in Paris he is not likely to make any mistake about the fact, and a thousand things will tell him where he has got to. Whether, if he arrived at Timbuctoo for the first time, he would be quite so certain where he was, is not so clear. But that if he were going a journey across the African desert, or across the Atlantic Ocean, he would soon find himself in a plight in which no

map would help him, is beyond all doubt. How, then, is the traveller to find out whereabouts he is upon the earth's surface? *How is he to discover in what longitude and latitude he stands at any given moment?*

The problem is one which has to be worked out every day by those who are at sea, and who have lost all guidance from the familiar outlines of the land. Let us inquire, therefore, how a sailor in mid-ocean finds out his longitude and latitude, or, in other words, discovers the exact point on the earth's surface over which he happens to be sailing at any given moment.

The Shadow on the Earth.

To understand this chapter properly it will be useful to begin with a simple experiment which will help to make clear the points we shall have to give attention to.

Hold up a ball in front of a bright lamp. The ball represents the earth, the bright lamp the sun. We shall see that half of the ball, that which is turned away from the lamp, is in **shadow**; the other half, that which is turned towards the lamp, is **brightly lit up.** Now let us mark two lines A and B upon the ball: one runs from the top to the bottom of the ball along that part of its surface which is nearest to the lamp, and which, in consequence, receives the fullest and brightest light. The other line is drawn exactly opposite to it, upon the dark side of the ball, and farthest away from the light. Now turn the ball slowly from left to right. The amount of light and shadow on the ball does not change: half of it still remains in the light, half of it in the dark; but what was formerly in shadow now passes into the light, and what was in the light now enters the darkness. By the time we have turned the ball half round the first line will have reached the position which the second line occupied at the beginning, while the second line will

now be in the place of the first—that is to say, exactly under the light, and brilliantly lit up.

Now let us be clear about one more matter before we begin to use our illustration for the purpose of explaining this chapter. Everybody knows that we are accustomed to divide the day into **24 hours**, of which, roughly speaking, twelve are hours of daylight, and twelve hours of night or darkness. We begin to count the hours from twelve o'clock in the day, or **midday**, as it is often called. What is this hour of midday? It is the hour at which the portion of the earth on which we stand is exactly opposite the sun--in other words, when it is in the position occupied by the line A at the beginning of our experiment. But as the ball revolves, we see that the line A passes out of the bright light into darkness, and that other parts of the ball come directly under the light of the lamp as the ball turns. But our earth turns on its axis just as the ball does, and as a natural result, each part of it comes into "**full light**," or **midday**, at a different moment. Now let us see what is the natural consequence of this. If people all over the world begin to count their time and to number their hours from midday, that is to say, from the moment when the particular part of the earth on which they stand has come exactly opposite the sun, then it is plain that, as the different parts of the earth's surface come directly opposite the sun, one after the other, twelve o'clock must be at a different time in every part of the world.

Such is, indeed, actually the case, and we shall see presently how this difference of time is made use of for a very important purpose. For the present all that is necessary is to understand that midday is the time at which any particular portion of the earth is exactly opposite the sun, and that from midday, whenever it comes, the people in every part of the earth begin to count the twenty-four hours which make up the day.

Meridians.

When making our experiment with the ball and the lamp we drew only two lines; but when we come to the earth's globe we must follow the example of geographers, who have agreed to divide it by lines, all running in the same manner as the lines on the ball—that is to say, from pole to pole. It need hardly be said that these are imaginary lines drawn only on maps or globes for convenience of measurement, and other similar purposes. These lines, we know, are called **Lines of Longitude** or **Meridians.** In addition to the lines of longitude geographers have agreed to draw another set of lines at right angles to them. These lines run round the globe parallel to the equator, and therefore, of course, parallel to each other.*

These lines, therefore, are called **Parallels** of Latitude. Any good atlas contains a map of the world with the meridians of longitude and parallels of latitude marked upon it. Every place has its meridian, and the number of meridians is therefore infinite. For map-making purposes, however, 360 meridians and 360 parallels only are used.

The Meridian of Greenwich.

As the earth revolves, each meridian in turn comes out of the darkness into light, passes under the sun, and moves round again into the night. The town of **Greenwich** is situated in latitude 51° 28′ N. Every place on this latitude has a different time, that is to say, Greenwich time is different from **Antwerp** † time, **Antwerp** time from **Dresden** time.‡ Both **Antwerp** and **Dresden** are nearly upon the same *parallel* of latitude as **Greenwich**. It is easy to understand why there should be this difference

* It is proved in Euclid Bk. I., prop. 30, that "lines which are parallel to the same line are parallel to one another."

† Antwerp is in lat. 51° 15′ N. ‡ Dresden is in lat. 51° 3′ N.

F

of time. When the revolving globe has brought Greenwich just opposite the sun, we say it is midday or **noon by Greenwich time.** But at the very same moment there is a spot on the same parallel of latitude as Greenwich, but exactly opposite to it on the other side of the globe, which is turned away from the sun, and is in darkness. There, too, it is 12 o'clock, but it is **midnight** instead of midday. Half-way between Greenwich and the point where it is midnight there is a point where the time is six hours behind that of Greenwich. Such a point will be about fifty miles west of **Lake Nepigon** in Canada. The globe must revolve for six hours longer before this spot comes directly under the sun. In the same way there is a spot to the east of Greenwich somewhere in the extreme **north-west corner of China** which passed under the sun six hours ago, and in which, in consequence, it is now six hours past midday, and on which the shades of evening are already falling. The meridians of longitude are, as we have seen, drawn east and west from Greenwich to the **180th deg. E. long.**,* and the 180th deg. W. long. In twenty-four hours **360** meridians will have passed under the sun. In twelve hours half the number, *i.e.*, **180**, in six hours **90**, and in one hour **15**. Thus, to say that Greenwich is divided from any place by 45 degrees of longitude is the same thing as saying that there is a difference of three hours in the time of the two places; when it is **9** o'clock a.m. at **Saratov** † in South Russia it will be **6** o'clock at Greenwich.[10]

Places Having the Same "Time."

But while all places at the same parallel of latitude have *different* times, all places in the same meridian of longitude

* The **180th deg. E. long.** and the **180th deg. W. long.** are identical. The 180th deg. lies to the east of New Zealand.

† Saratov is in lat. 51° 31′ N.

will have the *same* time. It is easy to see that when the meridian on which Greenwich stands is exactly opposite the sun, all places on any part of the same meridian will also be exactly opposite the sun, and they will all change their time together as they sweep round with the movement of the globe. Thus, when it is midday at Greenwich it will also be midday at **Lourdes** * in the south of France, and at **Christiansburg** † on the Gold Coast of Africa.

Now then, we have got some way towards understanding how the longitude of any place is found out. A place which is **1** deg. west of Greenwich will be **4** minutes slow of Greenwich time. Any place which is **1** deg. east will be **4** minutes fast. A place which is **90** deg. west will be **360** minutes or **6** hours slow.[11]

The Chronometer and How to Use it.

But if we can tell the time of any place as compared with Greenwich time provided we know its longitude, we can equally tell its longitude provided we know the difference between its time and that of Greenwich.

Can we find out this difference of time? and if so how? The persons who most often have to discover for themselves in what longitude they stand are captains of vessels in the open sea. Let us see how they set to work to find their longitude, and how they make use of Greenwich time for the purpose. Every captain who goes to sea takes with him a **chronometer.** A chronometer is simply a very accurate and well-made watch, arranged in such a way that the accuracy of its movement is not interfered with by the expansion or contraction in hot or cold climates of the metal of which it is constructed; or by the motion of the ship.[12] Before leaving port the captain sets his chronometer to

* Lourdes is in long. 0° 1′ W.
† Christiansburg is in long. 0° 0′.

Greenwich time, and during the whole of his voyage it keeps Greenwich time. Let us suppose that the captain be sailing from Liverpool to Quebec or Halifax. For the greater part of his journey he will be travelling westward along the 52nd parallel of latitude. Now we have already seen that the times of places in the same latitude are always different from one another. By the time, therefore, the ship has reached the **38th meridian of longitude**, half-way across the Atlantic, the captain will be in a place where the time is **2 hours 32 minutes slower** than that of Greenwich. For, as we saw, 15 degrees of longitude are equal to one hour of time. If he can only tell the time at Greenwich and the time at the place which the ship has got to, he will have solved his problem. Can he do this? Yes. As to the time at Greenwich his chronometer will tell him that, for it has gone on steadily marking the hours from the time when it was started on leaving. When the hand of the chronometer points to **12 o'clock noon**, the hand of the clock at Greenwich will also be pointing to **12 o'clock noon**. But at Greenwich the sun will have reached its highest point; while in the middle of the Atlantic it will only have risen a few hours.

An Observation of Longitude on Board Ship.

How soon will the sun be in the meridian of the position occupied by the ship?

That is the next thing the captain has to find out. By observation it is possible to find out when the sun has reached its highest point. The exact moment is noted, and the chronometer is examined. It will then be seen that midday on the ship corresponds with 2.32 p.m. at Greenwich—in other words, that there is a difference of **2 hours 32 minutes** between the times of the two places. But we already know that a difference of 2 hours 32 minutes in

time is equal to a difference of 38 degrees* in longitude. The ship, therefore is in longitude 38° W.†

But whether the observation be taken at nine o'clock or at noon, the way in which the position of the ship is worked out is the same. The difference between the ship's time and Greenwich time is noted, and the distance east or west from Greenwich is reckoned by allowing fifteen meridians of longitude for every hour of time. Thus, if when the sun, as seen from the ship, is at its highest point the chronometer marks **three o'clock**, the captain will know that he is **45°** west of Greenwich. But though he knows that he is 45° west of Greenwich, he is still very far from knowing exactly at what point on the earth's surface he has arrived. It will be easy to understand this by the help of an illustration. Suppose a sailing ship, the **Aurora**, leaves Liverpool for Quebec, and a week later a steamer, the **George Stephenson**, leaves for the same port. On the fifth day after leaving port, the captain of the **George Stephenson** takes his daily observation for longitude, and finds that there is a difference between Greenwich time, as marked by his chronometer, and "ship's time," as marked by the sun as seen from the ship, of two hours. As we have already seen, a difference of one hour in time is equal to 15° of longitude. The ship is therefore in longitude **30° west.** On the same day the captain of the **Aurora**, whose vessel has been struggling with strong north-westerly winds, and has now been twelve days at sea, comes on deck to take his observation. He too consults his chronometer, and finds, as the captain of the steamer did, that the

* 2 h. 32 m. = 152 m. Divide by 4 (four minutes to a degree of longitude) = 38 deg.

† In actual practice it is usual to make an observation of longitude at about 9 o'clock in the morning, and not at noon. The sun appears to move more quickly when it is low down than when it has reached its highest point, and it is easier, therefore, to tell the time of day by observing it when it is low down than when it is high up.

difference between his ship's time and Greenwich time is two hours. Plainly, then, he too is 30° west of Greenwich, or in *longitude* 30° *west.*

But is the **Aurora** in the same position upon the earth's surface as the **George Stephenson** is on the same day?

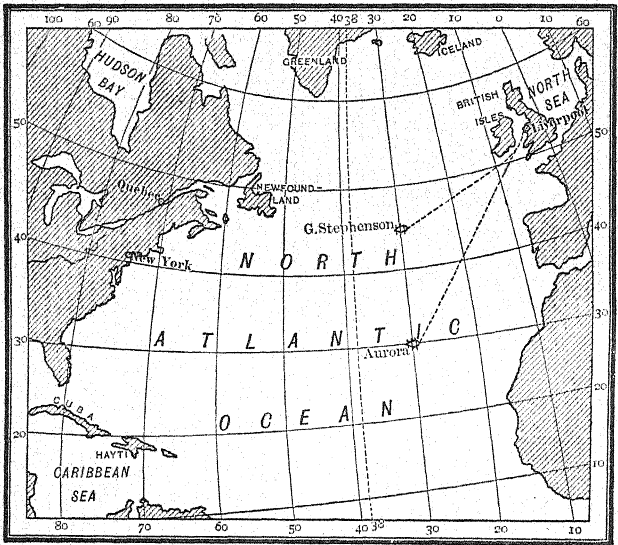

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Fig. 25.—Positions reckoned by Longitude and Latitude.

Possibly she is, possibly, however, she is in a very different position.

If we look at Fig. 25 we shall see that the thirtieth meridian of longitude runs right down the middle of the Atlantic; the **George Stephenson** may be on the direct line between Liverpool and Quebec, and the **Aurora** on the equator 3,600 miles south of Liverpool, and yet both vessels may be in longitude 30° west.

An Observation of Latitude.

Plainly it is necessary for the captains to know something more than the longitude. They must know their **latitude** also, and to find out their latitude they must make another and a different calculation.

How does the captain of a ship find out his latitude?

Before we can understand the answer to this question

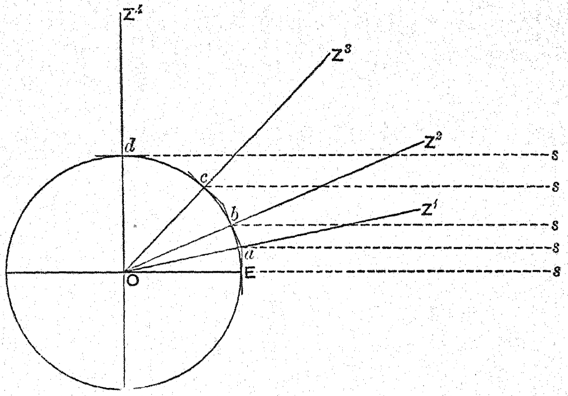


Fig. 26.—Diagram illustrating an Observation of Latitude.[3]

we must recall what we learnt in Chapter VI. We there saw the way in which a degree of latitude is measured.

In learning how to measure a degree of latitude, we really learnt how to determine the latitude of a place.

We saw in Chapter IV. that, as we go north or south from the equator, the position of the sun in the sky changes. We saw that *at midday at the equinox* the sun at the equator is exactly *overhead or in the zenith.* As we go north or south from the equator the midday sun appears lower down. The nearer we get to the poles, the lower down does the sun appear. Fig. 26 shows the position of the midday sun as seen from various parts of the earth's surface at the time of the equinox.

E is the equator, S the position of the sun as seen from the equator at midday. *a*, *b*, *c*, and *d* are different points of observation on the earth's surface. The lines drawn O Z^1, O Z^2, O Z^3, O Z^4, show the direction of the zenith at the different points of observation through which the lines pass. The straight lines touching the edge of the circle are the lines of the horizon at the different points; and the dotted lines *a* S, *b* S, *c* S, *d* S show the direction in which an observer at each point would have to turn his eye or his telescope in order to see the sun at midday.

The dotted lines *a* S, *b* S, *c* S, and *d* S, make an angle in each case with the zenith line. This angle is *greater* the farther we get from the equator. The angle S *a* Z^1 is a very small angle. An observer at *a* will only have to move his telescope a very little way to the south of the zenith point to see the sun.

At *b* the angle S *b* Z^2 is a larger one. The observer must look lower down to see the sun. At *c* the angle S *c* Z^3 is larger still; and by the time we get to the pole at *d* we have an angle, S *d* Z^4, which is a right angle. In other words, if an observer could stand at the pole to make an observation, he would have to bring his telescope down and point it straight towards the horizon, in order that he might catch a glimpse of the sun just peeping over the edge of the earth.

But, as we saw in Chapter V., it is not only possible to measure the angle between the zenith and the sun, at any point on the earth's surface, but it is possible also to make use of these angles when measured to find out the *exact distance from the equator or the pole* of the spot at which the observation is taken.

The Position of the Sun.

For instance, if the angle be 45°, we know that the point of observation is *half-way* between the equator and

the pole, for, the whole distance being **90°**, a spot which is on the 45th degree must be half-way. In the same way, if we find that the angle between the zenith line and the line to the sun is 10° only, we know that we are at a point one-ninth of the distance from the equator to the pole—in other words, in latitude **10° N.**, the latitude of **Sierra Leone** in Africa. Or, if we find that the angle is **60°**, we know that we are *two-thirds* of the distance from equator to pole, that is to say, in latitude **60° N.**, the latitude of **Christiania** in Norway.

As explained previously (p. 61), it is usual in practice to observe the angle between the line to the sun and the horizon, rather than that between the zenith line and the sun. This is merely for convenience. The one angle is the *complement* of the other, *i.e.*, the two together make up a right angle. In using the angle between the sun and the horizon, instead of that between the zenith line and the sun, it is only necessary to calculate out the other angle. Thus, if the angle be 80°, the observer will be in latitude 10° ($80+10=90$). If 45°, then in latitude 45° ($45+45=90$). If 30°, then in latitude 60° ($60+30=90$).

It is by a calculation of this kind that a captain of a ship at sea actually discovers his latitude. At midday he comes on deck and marks the position of the sun above the horizon. By the use of the instrument called a *sextant* he is able to find out exactly the angle which is made by the two lines, C S and C H, which are the lines from the point of observation to the sun and to the horizon respectively (Fig. 27).

Let us suppose that this angle prove to be one of **40°**, he then knows that he is at a place $\frac{50}{90}$ths, or $\frac{5}{9}$ths of the distance from the pole to the equator. For he knows that if the angle between the sun and the horizon be 40°, the angle between the sun and the zenith line must be 50° ($40+50=90$), and that he is therefore in **latitude 50°**.

Allowance for Declination.

But this is not all. We have taken our example throughout as if the sun were always in the position in which it stands at the equinox, that is to say, when it is exactly overhead at the equator But we have already seen

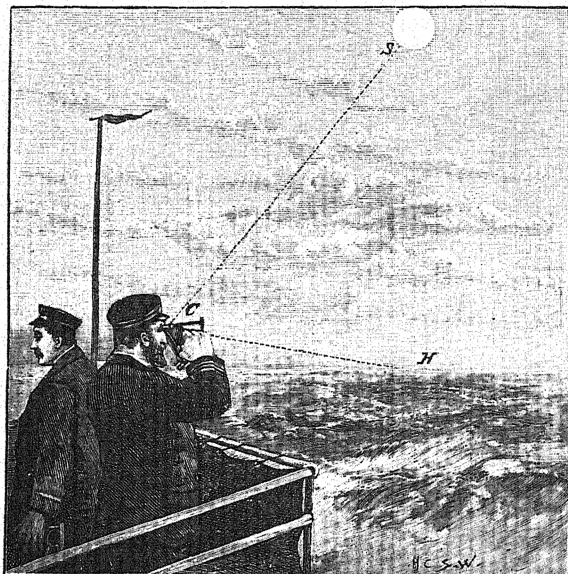


Fig. 27.—"Taking the Sun" at Sea.[8]

(p. 23) that the midday sun is not always in this position, but that, on the contrary, its position keeps on changing from day to day until, at midday in winter,* it is **23½°** **south** of the equator, and at midday in summer* **23½°** **north** of the equator. We learnt that this change in the position of the sun as observed from the earth is called the "**declination** of the sun," and the declination of the

* Winter and summer in the northern hemisphere are here spoken of.

sun must be taken into account when making an observation of latitude.

We shall see this clearly enough if we think for a little. Suppose the observation were made in lat. 60° on the 21st of June, and the observer calculated his latitude without allowing for the sun's declination, he would be sadly out in his reckoning. At the summer solstice (June 21st) the sun has a north declination of 23½ degrees, and is in the zenith, or exactly overhead, at midday, in lat. 23° 30′. But the observer, forgetting this, has reckoned as if the sun were in the zenith at the equator. He would find by observation that the angle between the zenith line and the sun was **36½ degrees only,** and from this he would reckon that he was 36½ degrees from the equator, in **lat. 36½° N.**, the lat. of **Cadiz,** in Spain, or **Norfolk,** in Virginia, in the United States, **instead of lat. 60° N.,** his real latitude, which is that of **St. Petersburg**, or **Kamschatka.** In order to *correct* his observation he would have to allow for the fact that the sun was 23½ degrees north of the equator.

The Nautical Almanack.

In practice an allowance of this kind has always to be made. The captain of every ship is furnished with a set of tables, called tables of declination, which are prepared at an office in London, and which are contained in a book called the **Nautical Almanack.** From these tables the captain can learn at a glance what is the declination of the sun on any given day in the year, whether it be north or south of the equator, and how many degrees north or south it is. When he knows this he has only to add or subtract the number of degrees in order to *correct* his observation of latitude. If he be sailing in the northern hemisphere he must subtract the number of degrees of declination from the angle between the sun and the horizon, when the sun is in north declination, and must add them

when it is in south declination. When he is sailing in the southern hemisphere the calculation will be reversed.

Now let us come back to the captains of the **George Stephenson** and the **Aurora**, who, as we have seen, have both of them discovered that they are in longitude 30° W., and have then taken steps to find out their respective latitudes.

Correcting an Observation.

The captain of the **George Stephenson** uses his sextant, finds out the sun's altitude—that is to say, the angle between the sun and the horizon—to be 55°. He takes his **Nautical Almanack**, and learns from it that the declination of the sun on that particular day is **10° North.** He subtracts 10° from 55°, and thus finds that the corrected angle is **55 − 10 = 45.** But we know that if the angle between the sun and the horizon be 45° the angle between the sun and the zenith line will be the complementary angle of 45°; that is to say **45°.** He is therefore in **45° N. lat.**

Meanwhile, the captain of the *Aurora*, who has done exactly the same thing, gets quite a different result. He finds that the **sun's altitude is 70°**, that is to say he is much farther to the south than the other captain. He, too, consults the **Nautical Almanack**, finds that the sun has **10° North Declination;** subtracts 10° from 70°, and finds to his great discomfort that the heavy head-winds he has had to fight against have driven him far south of his course; and that instead of being, as he hoped, in lat. 45 N., in a line with the Gulf of St. Lawrence, he is far down south, in **lat. 30° N.**, in a line with the coast of Florida.*

Fig. 25 shows the course and position of the two ships.

Thus, by taking the double observation of longitude and

* 70 − 10 = 60 : the complementary angle of 60° is 30°; hence he is in lat. 30° N. Q.E.D.

latitude on the same day, the captain of a ship can find out his exact position upon the surface of the globe, however far from land he may be. He has only to find the exact point upon the map or chart at which his line of longitude crosses his line of latitude, to be able to tell to a nicety where his ship actually is.[13]

Summary.

1. Sailors at sea must discover their longitude and latitude in order to find out the position of their ship.

2. Longitude is discovered by comparing the "local" or ship's time with Greenwich time.

3. Fifteen degrees of longitude are equal to one hour in time.

4. All places on the same meridian have the same time. All places on different meridians have different times.

5. It is not possible to discover the position of a ship by an observation of longitude alone.

6. It is also necessary to know the latitude.

7. The latitude of a ship is discovered by observing the altitude of the sun.

8. In calculating the latitude it is necessary to make allowance for the sun's declination.

9. By obtaining a correct observation of latitude and longitude, the exact position of a ship may be discovered.

Explanation of Terms.

Altitude (of sun).—The height of the sun above the horizon in degrees.

CHAPTER VIII.

MAPS AND THEIR USES.

What Maps can Tell Us.

EVERYBODY knows that **maps** and geography are connected, and that in studying geography it is well to have the help of a **map**. But though this knowledge is common enough, the knowledge of how to use a map rightly, and to connect the drawing on a piece of paper with the actual surface of the world of which it represents a part, is by no means so common. It is well, therefore, to give up a chapter to considering what a **map** is, and how it should be used. The object of a map of course is to give us in a convenient shape, and on a small scale, such a picture of the country represented as will convey a real idea of the actual country as it exists.

Of course there are a great many things which no map, however good, can ever give. No map can give us any idea of the appearance of the landscape, of the vegetation which covers the ground, of the customs of the people who live on it, of the character of the atmosphere; and it can tell us but very imperfectly the distribution of population, of plants, and of minerals. Some things, however, a map can tell us with perfect accuracy. Not only can we learn from a map the position of a place, the direction of a particular river, or the height of a particular mountain, but, what is much more important, the **position of one place "in relation to another,"** and "in relation to" other parts of the world; the **direction**

of a river or road **as compared** with some other river or road, and the **height** of one mountain **as compared** with another. A map will also give us a perfectly correct idea of **outline**—that is to say, we may learn from it the

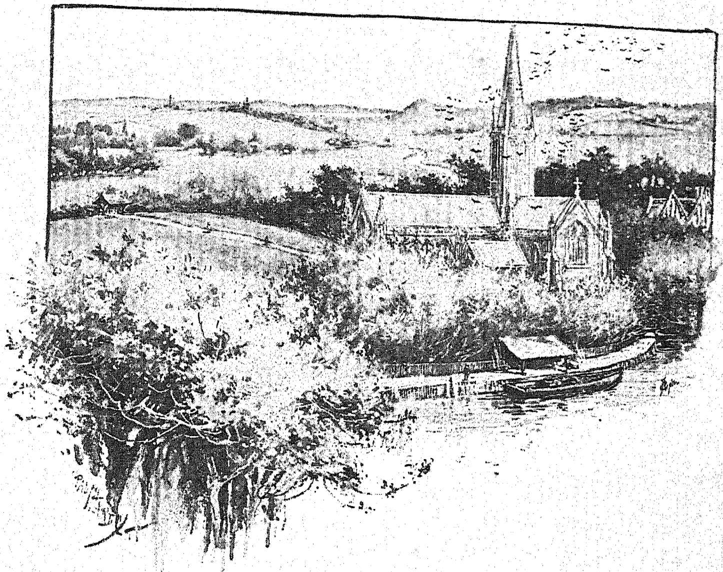


Fig. 28.—A Piece of Country to be Mapped.

form of continents and islands, and can see at a glance the indentations and projections on their shores.

Scale and Proportion.

Now let us see how a map can give us all this information. What we have to start with is an expanse of country —it may be a small area of a few yards or a few miles, or it may be the whole surface of the globe. What we have to end with is a drawing upon a piece of paper which will give

us accurately about this tract of country the information of which we have spoken above. Let us begin with things on a very small scale. Fig. 28 is a picture of a small piece of country. We must imagine to ourselves that this piece of country is as large as it would be if we actually saw it in nature, for unfortunately in a book we cannot have all our examples just as we wish them. But if anyone wishes for a real example, he can find one for himself outside his own door at any time. Let us suppose, however, that we have before us a piece of ground such as that which is shown in the picture. It is of this ground that we have now to make our map. It is the map-maker's business to give all the information he can about the country he is mapping. What are the chief features which he will have to notice and record in the landscape before him?

Landscape and Map.

In the foreground is a river with a boat upon it. On the river-bank stands the church. The church itself will tell us where to look for the north, for if we stand with our back to the church and the "east window" on our right hand, the **north** will be in front of us. In this case, therefore, we may guess that the north lies in the direction of the wooded hill in the distance. But as we shall see, we do not depend upon any such guide when we come to our map-making, but shall have to find out the north by a much more certain plan. The stream winds down the valley beyond the church, and the path crosses the fields on the left. Farther down the valley we see a wood. In the distance, the wooded hill rises on the right bank of the stream, and at the farthest point in the view we get a glimpse of the stream broadening out into a lake just visible to the left of the wooded hill.

Now all these features must be described in the map if it is to tell us a true story; and if we look at Fig. 29 we

shall see how the map-maker has done his work. But there are one or two things which our picture and our plan do not make quite evident. A piece of country such as that which is represented in the picture would really be **3 miles long and 2 miles broad**, and if we measure the plan or map, we find that it is no more than **3 inches by 2 inches.** Now until something more has been done by the map-maker than what we have already seen, we shall not be able to learn from this map a great deal that a good map ought to tell us. If we were to walk with a measuring tape from the church to the bend of the river, we should find that the distance was one mile. If we look on the map it is true that we find the church and the bend in their proper places, but we have no idea as to **how far** the one is from the other, nor can we form any idea until the map-maker has given us a **scale.** The meaning of giving a scale is very simple; it means that the map-maker has told us what proportion he has allowed between the real size of the country represented and the size of the plan or map which he has drawn. In making the map he decides

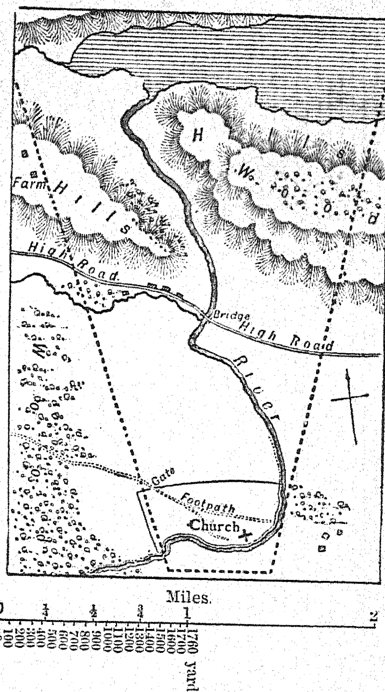


Fig. 29.—A Map of Fig. 28.

that every measure of length upon the real country shall be represented on the map by another and smaller length.

Proportion.

It does not matter whether the difference between the actual measurements and the measurements on the map be large or small, the only thing that matters is that when once the size of the map has been settled, all the distances shall be *in true proportion*. For instance, let us say that the whole tract of land of which the map is to be made be 3 miles by 2 miles. The map-maker finds that the sheet of paper on which he has drawn his map is not 3 miles by 2 miles, but 3 inches by 2 inches. If, therefore, 3 inches is to represent upon the map 3 miles upon the actual face of the country, it is plain that 1 inch must represent 1 mile upon the surface of the country, and half an inch half a mile, and so on. Now if we come to bring the miles which give the distance along one side of the real country to inches, we shall find that each mile contains 63,360 inches. It is easy to see what is the **proportion** between the piece of land and the drawing which represents it.

Any distance measured as the real piece of land is 63,360 times the length of the representation on the sheet of paper; or to put it in another way, the map is $\frac{1}{63360}$th part of the size of the actual piece of land.

Distance.

We have now got the **proportion** or **scale** of our map, namely, one to 63,360, which is generally written thus on the map $\frac{1}{63360}$. The meaning of this we shall see the moment we come to study the map. By means of the scale we shall now be able to tell not only the **positions** of places marked on the map, but the exact **distance** between any two places. If the distance between the church and the mouth of the river on the map be $2\frac{1}{4}$ inches, we know at once that the

real distance between the two on the actual surface of the ground is $2\frac{1}{4}$ miles, *i.e.*, 63,360 times $2\frac{1}{4}$ inches.

But there is a second thing which we said just now a map ought to be able to tell us with absolute certainty. It ought to give us correct information about position, and not only about position, but about the position of one place **as compared** with another. We shall see the importance of the last part of this sentence in a moment. If, for instance, a map were to tell us that the town of **Warwick** is situated in the centre of England, and that **Manchester, Hull, London,** and **Bristol** are 90, 115, 90, and 75 miles respectively from **Warwick,** we should really be very little the wiser, and there would be nothing to prevent a person who was guided only by the map from starting from Warwick on his way to London and expecting to find Manchester or Bristol on the road. It is true that he would be disappointed, for he might walk for ever and never reach one of the places of which he was in search; yet, strictly speaking, the fault would not be his, but that of the guide who could give him no better assistance than telling him the distances only. There are many ways of giving a person a right direction when he is looking for any place. "Go down the street and take the first turn to the right" is a very common form of direction, and sometimes a very serviceable one. But it is easy to see that there are occasions in which it may mislead. For instance, whether the direction prove right or wrong will entirely depend on whether the person to whom it is given be going up or down the street. A person who is walking along Oxford Street, London, from the Marble Arch towards Holborn, will, if he turn to the right and keep straight on, arrive in course of time somewhere about **Eastbourne** on the coast of Sussex. Whereas, if he happen to be going from Holborn to the Marble Arch and follows the direction given him, he will strike the sea somewhere about North Shields on the

coast of Durham. Plainly, therefore, a mere direction to turn to the right or the left is of no value for general purposes.

The Points of the Compass.

In order to give a direction which will never mislead and which will serve a person in any part of the world, it is necessary to have some **fixed point** which all persons may agree upon, and which everyone will have clearly in his mind when he is told to go in a certain direction either to the right or to the left. We know of course that in practice the point, or rather the points, upon which all people are agreed are what are called the **points of the compass.** In any country in the world a man who is told to look to the north will turn his face towards the same point, and when his face is so turned the south will be at his back, the east will be on his right hand, and the west on his left hand. Now what is this **north** point which serves as a guide all the world over?

The North.

We know that the world is shaped something like an orange—that is to say, it is a sphere flattened at the top and at the bottom, in scientific language an "Oblate Spheroid." We have seen also (Chap. II., p. 12) that the axis of this oblate spheroid is inclined to its orbit at an angle of $66\frac{1}{2}$ degrees. Now if we take an orange to represent the globe and put a knitting-needle through the round marks at the top and bottom of the orange, the needle will give us a fair idea of what is meant by the **axis** of the earth (Fig. 30). The **axis** of the earth is the line running through the two poles on which the globe revolves. So in our example the places where the knitting-needle comes out at either end represent the two poles, north and south; and the needle itself will represent the axis. A line drawn from the north pole to

the south pole over the surface of the orange at any part will be the shortest distance between north and south. Any number of such lines may be drawn and they will all be the same length. At any spot on any one of such lines the pole may always be found by following the line up or down to the line of the axis from which they all start at the top

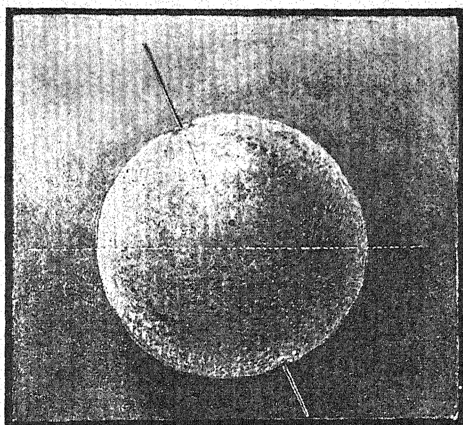


Fig 30.—The Earth as an "Orange" in Space.

or bottom of the orange. So it is with the surface of the globe. On every part of it a line drawn straight up to the north pole will end in exactly the same place as a similar line drawn to the same point from any other spot. And in the same way, any number of lines drawn downwards will meet in the same place at the south pole. It is not difficult, therefore, to understand what is meant by north and south, and how it comes about that in whatever part of the world we happen to be, the north is always a fixed point.

Now that we have learnt what is meant by north and

south it is easy to see what is meant by the other two "points of the compass," east and west. In whatever part of the world we stand, if we turn our faces to the north we shall speak of everything on our right hand as lying to the **east**, and of everything on our left hand as to the **west**. The four chief points of the compass, North, South, East, and West, are called the "**Cardinal Points.**"*

Fig. 31 represents the compass **card**, on which are marked the four cardinal points and 28 other divisions. The 32 divisions are called the "Points of the Compass."

The following are the names of the 32 points in their order, beginning from the north :—

NORTH. N.
NORTH by EAST. N.b.E.
NORTH NORTH EAST. N.N.E.
NORTH EAST by NORTH. N.E.b.N.
NORTH EAST. N.E.
NORTH EAST by EAST. N.E.b.E.
EAST NORTH EAST. E.N.E.
EAST by NORTH. E.b.N.
EAST. E.
EAST by SOUTH. E.b.S.
EAST SOUTH EAST. E.S.E.
SOUTH EAST by EAST. S.E.b.E.
SOUTH EAST. S.E.
SOUTH EAST by SOUTH. S.E.b.S.
SOUTH SOUTH EAST. S.S.E.
SOUTH by EAST. S.b.E.
SOUTH. S.
SOUTH by WEST. S.b.W.
SOUTH SOUTH WEST. S.S.W.
SOUTH WEST by SOUTH. S.W.b.S.
SOUTH WEST. S.W.
SOUTH WEST by WEST. S.W.b.W.
WEST SOUTH WEST. W.S.W.
WEST by SOUTH. W.b.S.
WEST. W.
WEST by NORTH. W.b.N.
WEST NORTH WEST. W.N.W.
NORTH WEST by WEST. N.W.b.W.
NORTH WEST. N.W.
NORTH WEST by NORTH. N.W.b.N.
NORTH NORTH WEST. N.N.W.
NORTH by WEST. N.b.W.

* Latin, *cardo*, a hinge. The other points are supposed to hinge or turn on the four principal or "cardinal" points.

We know that a circle is made up of 360 degrees; if, therefore, we divide 360 by 32 we shall find that between any two points on the compass there is an angle of $11\frac{1}{4}$ degrees. Of course it is equally possible to divide the compass into much smaller divisions than the 32 points, but for practical purposes the division into degrees and minutes is found sufficient for use.

We shall now see how the difficulty which we spoke of in the case of our poor traveller setting out from Warwick may be avoided. If we had told him that Manchester lay 90 miles **north-west** of Warwick, that Hull was 115 miles **north-east**, Bristol 75 miles **south-west**, and London 90 miles **south-east**, he would have had very little difficulty in finding the town which he wished to reach. And in the same way, the confusion which we saw might arise in the case of a person walking along Oxford Street and trying to learn his way by asking whether he should turn to the right, is got over the moment we tell him that the turn he is to take is on the **north side** or the south, for there is only one north side to Oxford Street and one south side; and if we go back to our map we shall see that, if it be correctly done, it will give us information not only about distances, which we have seen it is able to do, but also about directions.

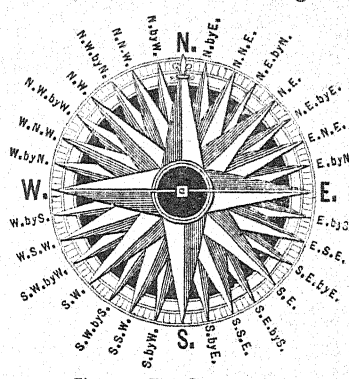


Fig. 31.—The Compass Card.

One of the first things the person who draws the map has to do is to pick out some point on the surface of the ground which is directly between him and the

north—that is to say, which lies to the north of him. This point he will put down on his paper, and when he knows where the north is, he will know where the south, east, and west are. He will then put down on the map a *Pointer*, such as that which is shown in Fig. 29; the end of this pointer, if correctly drawn, will be in the direction of that object which he found in the first instance to be due north upon the land. Then it is plain that a line drawn at right angles to the pointer will give a true direction east and west. And now the map will be able to teach us a great deal more than we could at first learn from it. We should know not only that the bend of the river is one mile from the church, but also that it is directly to the north of it. The stream, of which we were only able to measure the length before, will now be easily shown to run from south to north.

Which is the North?

Of course it is natural to ask how are we going to find out **which is the north** and **which is the south**, when we are going to draw a map and have only a piece of country to look at. There are a good many ways in which we can find this out. In the first place the sun will help us to find out the north. As we have already seen (Chap. II.), the earth in reality goes round the sun; but it appears to us upon the earth as if it were the sun that revolved round the earth. This, of course, is due to the fact that the earth, in addition to going round the sun, revolves on its own axis, and thus presents a different portion of its surface to the sun at every moment during the twenty-four hours. We all know that the sun when it first appears, or as we say, rises, in the morning is in the east, and that it sets in the west. At sunrise the sun is seen low down along the surface of the earth; as the day goes on the sun appears to rise higher and higher, and is seen more and more to the south in the sky till midday, when it sinks again towards the west.

Now it is plain that if between sunrise and sunset the sun appears to circle round at an unchanging rate of speed (1) from east to south, and (2) from south to west, that by the time it is half-way on its course it will have reached a point exactly half-way between east and west, in other words that it will be **exactly due south.** If we know which is the south it

Fig. 32.—Long Shadow in the Morning and the Evening.

will not be difficult to find out which is the north. How then can we tell when the sun is exactly half-way on its daily course?

How to Find the North.

Here is a method by which we can find out. If we go out in the early morning when the dew is on the grass, and the sun like a great ball is just rising up over the horizon, we shall notice that our shadows fall long and

black along the ground towards the west (Fig. 32). As the day goes on, and the sun rises higher and higher, the shadows grow shorter, till at midday in summer-time our bodies will cast a shadow much shorter than themselves

Fig. 33.—Short Shadow at Midday.

(Fig. 33). Then later in the day the shadows again begin to lengthen, until at sunset we see them stretching far away from us towards the east. *It is at the moment that the sun is highest that the shadow is shortest,* and we have seen that the sun is highest when it is midway between east and west, or in other words, when it is due south. If then we can find out when the shadow is shortest, we shall know when the sun is due south.

The Teaching of the Shadow.

Let us try a simple experiment. Let us place a stick upright in the ground on a sunshiny morning. It is not hard to tell when it is nearly midday, a look at our watch will tell us it is nearly twelve o'clock. Let us note where the shadow of the stick ends, then let us measure the distance from the foot of the stick to the end of the shadow. We find that it is 3 feet long. If we wait a few minutes and look again we shall find that the length of the shadow

has altered, and that it has become a little shorter than it was before. We wait again, and once more we measure the shadow. This time we find that it has grown longer instead of shorter. What does this tell us? It tells us that during the few minutes in which the shadow has passed from the first point at which we measured it to the last, the sun has reached its highest point; in other words, that during that period it has been due south of us.

Now by very careful examination of the length of the shadow, we might tell almost exactly at what moment the shadow was at its shortest, and if we could tell that moment we should know precisely when the sun was **due south** of us.

But such an observation is difficult in practice, for the alteration in the length of the shadow before and after midday is very slight, and it is easy to miss the exact moment at which it begins to grow longer. There is, however, a simple way of arriving at the result we want. Let us measure the length of the shadow, not at midday, but some three or four hours earlier—say at 9 o'clock in the morning. We find the length is four feet. We then take the stick as a centre, and with a piece of string the exact length of the shadow, draw a circle O O round the stick. Let us remember that every part of the circumference of a circle is at the same distance from the centre. Now we have drawn our circle we must wait till midday has come and gone, till the shadow which at first grew shorter and shorter, and fell within the circle, has begun to grow larger again, and to approach once more the circumference of the circle. At length, at 3 o'clock the shadow will again touch the circle, not at the same point where it touched it in the morning, but at a point on the other side of the post. If we draw lines from the foot of the post to the two points on the circle, we shall have a

figure like this (Fig. 34). While the shadow has been passing from A to A′ the sun has risen to its highest point, and has sunk again to the same height at which it appeared when we first measured the shadow in the morning. Exactly half the time the shadow, was growing shorter and the

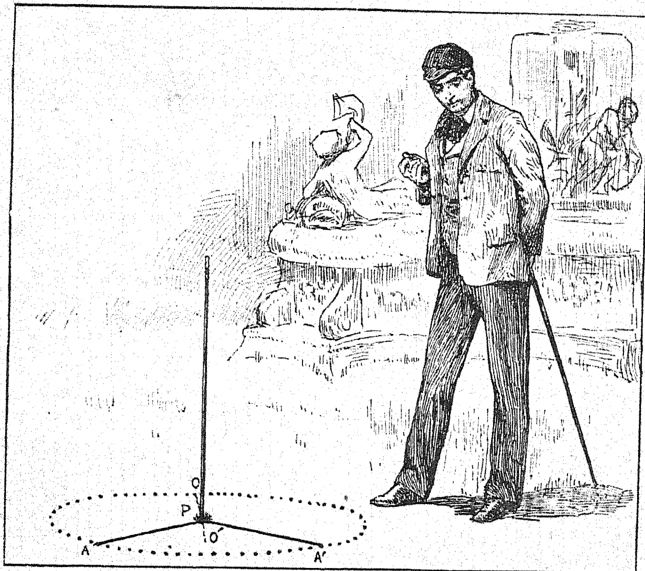


Fig. 34.—Taking the Time.

sun rising higher; during the other half, the shadow was lengthening, and the sun sinking lower. All we have to do, therefore, is to *halve* the distance between A and A′. This is easily managed; the point O is half-way between A and A′. Then let us join the foot of the post P and the point O, and the line P O will be the line upon which the shadow was cast at midday, that is to say, when the sun was exactly in the south. But if we know which is the south, it is easy to tell which is the north. The line from O to P if continued

through P will give us the direction towards the north, but we have only got to continue the line from P to O′ and we shall have a line pointing due north.

The Meridian.

This line on which the sun throws a shadow at midday is called the line of the "**meridian,**" or middle of the day, and as soon as we have found the line of the meridian in any place, it is easy to draw a line which will tell us which is east and which is west. If, with our face to the north, we draw a line at right angles to the line of the meridian, the line will point due east upon our right hand and due west upon our left hand. And, as we saw just now, it is easy when we have laid down the four **cardinal** points, to divide the whole circle into the 32 points of the compass—into degrees, minutes, or seconds as we please. Here then is one method by which we can find out the direction of the places which we wish to put down upon our map.

Finding the North by the Pole Star.

There is another way by which we can find out which is north. The method we have just described is one which can only be used by day; that which we are now going to consider must be used by night.

Everyone who has ever used his eyes to any purpose must have seen the great **constellation** or group of stars which is known as the **Great Bear**, and which is sometimes called "**Charles's Wain.**"

> "In the early spring as the nights grow shorter,
> Some clear cold eve when the clouds are high,
> Just as you're going to bed, my daughter,
> Linger, and look on the northern sky.
>
> There you will see, if the stars you're wise in,
> Over the edge of the darkened plain,
> One by one in the heavens uprising
> The seven bright beacons of Charles's Wain."

There are seven stars in the Great Bear, or rather there are eight, but one is so small that it is not easily seen with the naked eye. But it is with two of the bright stars only that we have to do at present. These stars are the two last in the constellation, and are marked β α in the picture (Fig. 35).

The "Pointers" of the Bear.

They are known as the "**pointers**" of the Bear. They are always pointing at something: let us see what it is. Follow the direction in which the two stars are pointing, and you will notice a single bright star with no other star of equal brightness near it. This is what the pointers are pointing at. It is the **Pole Star** which, to observers in every part of the northern hemisphere, marks the north. It is true that the Pole Star is not exactly in the true north, but it is very near it, and by means of it we can find out exactly where the true north is. A straight line continued through the axis of the earth would pass through what is known as the **Pole of the Heavens.** It would not pass through the Pole Star, but it would pass, or appear to pass, very near it. Now the Pole Star is always circling round the pole of the heavens, which is exactly over the north pole of the earth. If, therefore, we note the position of the Pole Star at any point in its journey round the pole, and then note it a

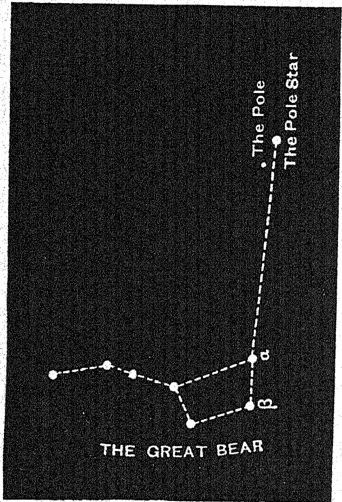


Fig. 35.—The Great Bear and the Pole Star.

second time twelve hours later, we shall have seen it in two positions equally distant from the pole, and exactly opposite each other. A line joining these two positions must pass through the actual pole or centre of the circle round which the Pole Star moves. If we draw such a line, and find the middle point in it, that point will be the true pole, and will be exactly over the north pole of the earth (Fig. 36).

It is in this way that the **true north** can be discovered by an observer on the earth. He marks the position of the Pole Star in two places at an interval of twelve hours, and the middle point between the two positions is the direction of the true north. Here then is another way by which we might get the direction of the places marked upon our map.

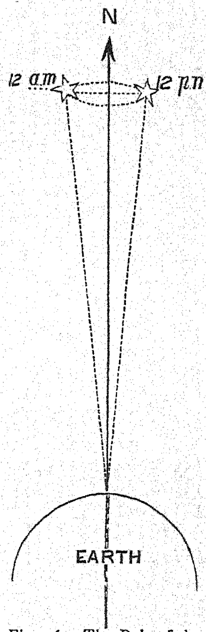


Fig. 36.—The Pole of the Heavens.

The Mariner's Compass.

There is yet another way which must be described here, and it seems in many respects to be the simplest of them all. We spoke just now of the compass, and the points of the compass. We must not confuse the compass of which we then spoke with the **mariner's compass** which we are now going to use to help us in our map-making. The mariner's compass is an instrument formed out of a magnetised needle balanced upon a fine point. This needle is usually placed in the centre of a circular **card** on which the points of the compass are marked, or more often the card is fastened on to the top of the needle, and moves with it. The needle, being finely balanced, is easily affected by the earth's magnetism. and it is found that it always points in a direction which is

more or less nearly north and south. It is customary to speak of the compass needle as pointing to the north, and "true as the compass to the pole" has become a common saying. But it is not correct, at the present time, to say that the needle points to the true north. As a matter of fact, the compass needle in London at the present time points not to the north pole, but in a direction 16° 40′ west of the north pole. This difference between the direction of the compass needle and the true north is called the **variation** of the compass, and before we can make any use of our compass, it is necessary for us to know the exact amount of the variation. This variation is not always the same in the same place. It changes from year to year. Sometimes the true north and the north as pointed out by the magnetic compass, which is called the **magnetic north**, are almost identical, sometimes there is a difference of many degrees between them.

Variation or Declination of the Compass.

Nor when we have found out the difference in London have we done all that is necessary. The variation of the compass is by no means the same in all parts of the world; and observations have therefore to be made in many stations and in different countries before the compass can be properly used.

Now, however, that observatories have been built in many places, and that many skilled observers have been trained in all civilised countries, a great number of facts have been collected, and the variation of the compass at any given time, in any part of the globe, is known. If once we know for certain the difference between the magnetic north and the true north, our compass becomes a very useful instrument indeed, and will help us greatly in our map-making. We can take the direction of any object and any place by our compass, and we shall then only have to

correct the direction, or bearing as it is called, by allowing for the variation of the compass in order to obtain a direction which is absolutely true.

Further Examination of the Map.

Now let us go back to our map on page 81. By the help of the shadow, or by the use of the compass, we have been able to find out which is the north, and to draw the pointer in the corner with its four arms, north, south, east, and west.

Mountains.

We have seen how the surface of the country is represented by the map, how the position of places and objects is marked, how the course and direction of rivers and roads are shown, and how hills or mountains are indicated. In our map a line of hills is seen along the edge of the lake. The hills are marked by shaded lines, the darker the shading the higher the ground. This way of showing the hills does not, however, tell us all we want to know about them. The thing we generally want to know about a mountain is its **height**. There are two ways of marking the height which are adopted by map-makers. One way is simply to write the height in feet upon the map. Thus, in Fig. 37 we have a shaded drawing of **Scawfell** in Westmorland, and some of the mountains near it. The height of each point is printed in figures: 3,161 feet, 2,572 feet, and so on. This plan tells us more than we learn from the shading alone; but though it is important to know the heights of the peaks, that is not all we require to know to get a true idea of the character of the mountains. Helvellyn is one of the highest and most striking of the lake mountains. On one side of it are steep grass slopes, and on the other side are crags and precipices falling sharply into the valley below. A shaded map such as that given

in Fig. 37, with figures at the top, will give us an idea of the shape of the mountain, and will tell its height, but it will not give us a true idea of the mountain's side as we really see it, here sloping smoothly, there

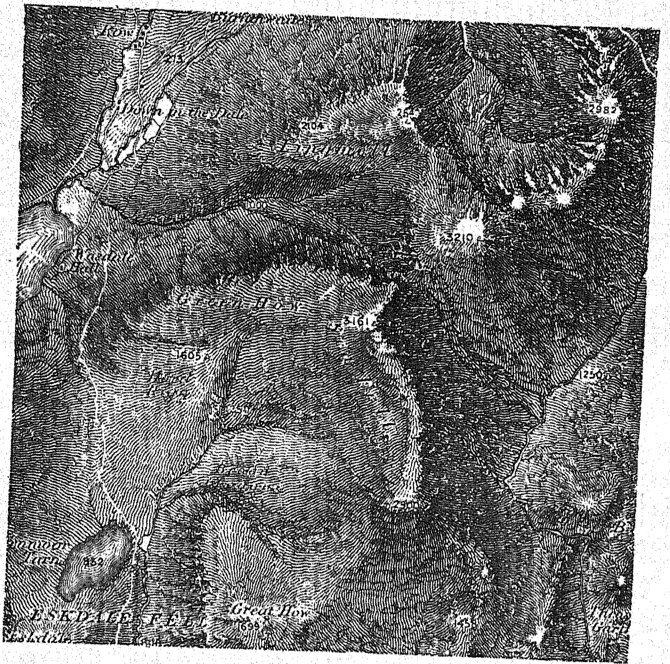


Fig. 37.—Scawfell (portion of the 1-inch Ordnance Map).
Reproduced same size.

breaking off into a steep cliff, or dipping into a small valley. There is, however, a way of showing mountains and hills which gives us this information with great accuracy, and by which we are able to build up an almost perfect model of the mountain without seeing it. This method is called "**Contouring**" and consists in drawing the *contours* or

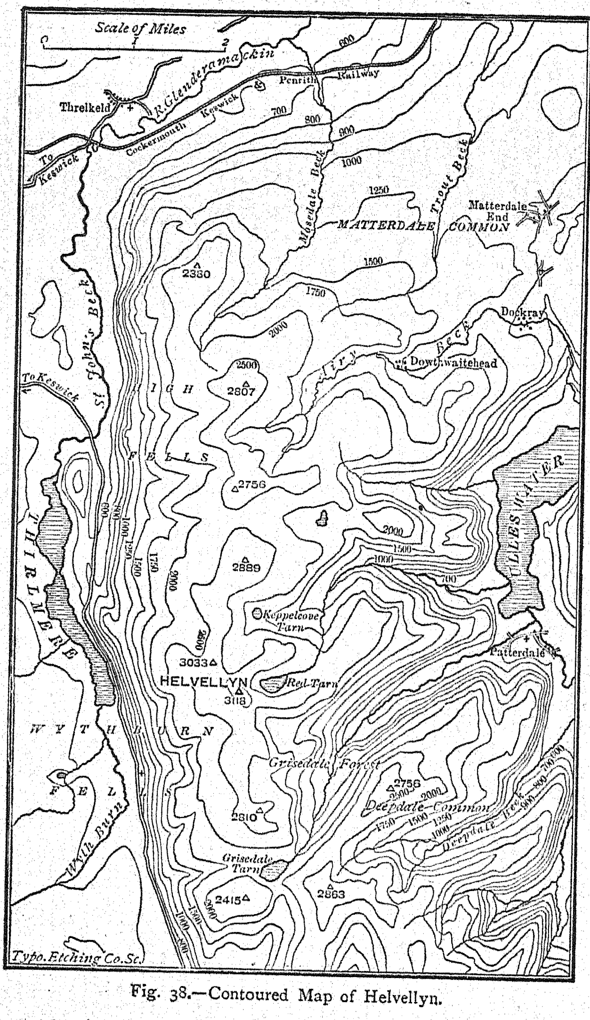


Fig. 38.—Contoured Map of Helvellyn.

outlines of the mountains at different heights. Fig 38 will explain the plan better than can be done in words. It represents Helvellyn drawn in "contour lines."

Contours.

A single experiment will show us what is meant by "contour lines." Fig. 39 represents four blocks of metal

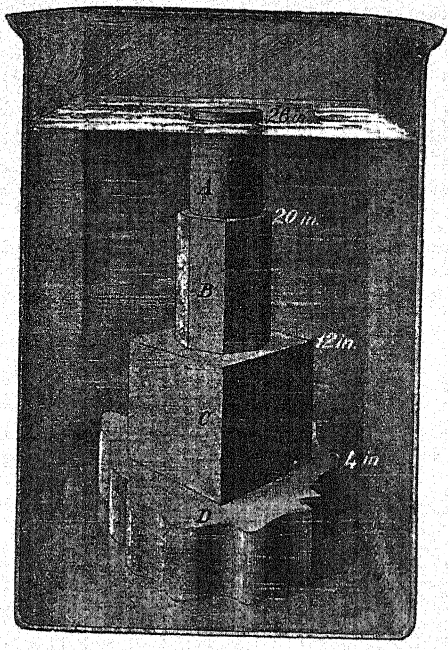


Fig. 39.—An Object to be Contoured.

of different shapes, marked A, B, C, and D, placed one upon the other in a glass tank full of water. The highest point A just appears above the water. Let us follow the outline made by the water round A at that point. It will be

of the shape of the inner circle in Fig. 40. This, then, is our first contour line, and represents the outline of the pile of blocks at a height of 26 inches. Now let the water run off till it falls to a height of 20 inches, and let us trace the outline of the block B at the point. This time our contour line is in the shape of the second figure in the diagram.

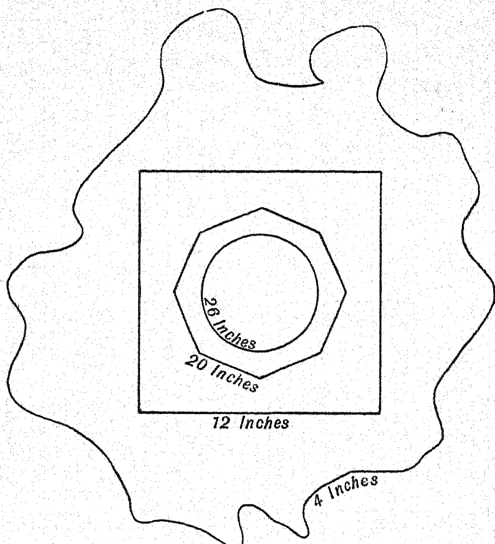


Fig. 40.—Contours of Object in Fig. 39.

With the water at 12 inches we repeat the process, and get a third contour line, the square; and, finally, when the tank has run nearly dry, we get a fourth contour drawn round the block D. Now let us draw these four contour lines one within the other, and add to each of them a number representing the height at which they were taken. We shall then have a map or plan from which we could, if necessary, build up just such another pile as the one in the tank.

Nature's Contour Drawing.

Nature herself often furnishes us with a good lesson in contour drawing. If we stand by the side of a pond just after a flood has passed through it, we shall see along the banks a succession of lines of sticks, straw, and leaves, one below the other. These lines mark the different points at which the water has stood as it receded. The lines follow every fold of the banks, they run into the little bays, they cling to the sides of the steep places, they fringe the sandy shallows, each line standing at the same height all round the pond. These are true contour lines, and by looking at them we shall learn how the plan of contouring can be used to represent the heights and outlines of a mountain.

Helvellyn.

In the map of Helvellyn each line is drawn right round the mountain, and represents the exact outline which would appear if the mountain were surrounded by water up to the point at which the line commences. Every point on the line numbered 600 is at a height of 600 feet; on the line 800 at 800 feet, on the line 1,000 at 1,000 feet, and so on.

It is easy to see which side of the mountain is sloping, for there the contour lines are far apart. A person descending must walk many yards along the surface before he gets down 600 feet.

It is equally easy to tell which is the steep craggy side. There the contour lines crowd in closely together. In many places the climber has but a few yards to go in a horizontal direction while he is clambering down his 600 feet.

Sometimes where a steep cliff stands up straight, the contour lines will actually join at its foot, for the top will stand exactly over the bottom.

It requires a little practice to master the art of reading contour lines easily; but it is worth taking some trouble to become familiar with this very useful and important part of map-drawing.

Sections.

Sometimes it is desirable to have a drawing which will show more than either a plain map or a contoured map. For instance, when a road or a railway is to be built, it is often very important to know exactly what will be the difficulties to be overcome in joining any two points. In such a case it is often useful to prepare a "**section**" of the country which is to be traversed. A section simply means a cutting, and the commonest example of a section is a railway cutting such as we pass through every time we travel by rail.

Any such cutting is really a section of the surface of the country through which it runs. The railway line is level from end to end, and if we know the height of the top of the cutting at various points, we can get a good idea of the surface of the country through which the cutting passes.

But it is quite possible to draw sections without cutting them, and to make a map or plan of the outline of a long stretch of country by measurement alone.

Fig. 41 is a section through the continent of **South America.** It is important to remember, however, that in

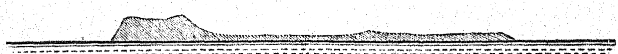


Fig. 41.—Section across South America.

such a section, and in almost all sections that represent great stretches of country, the height has been exaggerated in comparison with the length. Unless this were done, it would be necessary either to make the section so long that no book would contain it, or else to make the heights so

small that the eye would scarcely detect them on the page. It is easy to understand this when we remember how very little even the highest mountains stand up above the surface of the earth. *The top of Mount Everest*, the highest of the Himalayas, is 29,000 ft. above the sea. 29,000 ft. is a little over five miles, but the chain of the Himalaya Mountains in which Mount Everest stands is more than a thousand miles long, so in drawing a section of the Himalayas the line would have to be 200 *inches*, or more than sixteen feet long, in order to allow of our representing Mount Everest by a line

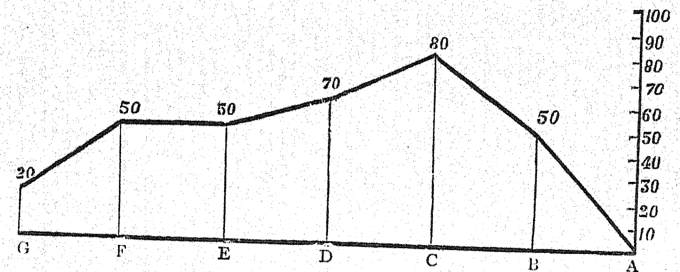


Fig. 42.—Diagram of a Section.

one inch high. For convenience sake, therefore, it is usual in drawing long sections to make the heights greater and the distances smaller in proportion than they really are.

Such a section can be roughly drawn by anyone who walks over the country; but it is only by the greatest care and the closest measurement that it can be made quite accurate. To make such a section of any real use it is necessary to find out the exact difference of height between a number of places on the line of the section. This is done by means of an instrument called a **Level.**

When the different heights are known, it is easy to draw the section. For instance, suppose A, B, C, D, E, F, and G, in Fig. 42, are points each a mile from the other on the line of a section, and that A is on the sea-shore, or, as map-makers

say, at the sea-level. By means of our level we find that B is 50 ft. higher than A, C 30 ft. higher than B, D 10 ft. lower than C, E 20 ft. lower than D, F the same height as E, and G 30 ft. lower than F. Then, by drawing lines in the proportion of 50, 80, 70, 50, 50, and 20, and drawing a line from A, joining the tops of them, we shall get the section we require.[14]

Summary.

1. A map can give us information as to distance, height, position, direction, outline.

2. A map is a representation of an actual portion of the earth's surface.

3. All distances on a map are proportional to the distances between the earth's surface which the map represents.

4. "Direction" in a map is given by use of the points of the compass.

5. There are 32 points in the compass, including the four cardinal points, north, south, east, and west.

6. It is necessary to know the direction of the four cardinal points before making a map of any piece of country.

7. If the North be known we can tell the direction of the other points of the compass.

8. The North can be found in several ways—
   (*a*) by observation of the shadow cast by a stick,
   (*b*) by observation of the Pole Star,
   (*c*) by the use of the mariner's compass.

9. The height of objects in maps is indicated in various ways—
   (*a*) by shading,
   (*b*) by figures,
   (*c*) by contouring.

10. The heights of different parts of a country along a given line are often shown by sections.

CHAPTER IX.

CLIMATE.

What is Meant by Climate.

WE all know, roughly speaking, what is meant by the word **Climate.** We speak of a country or a place having a good climate, and we mean not merely that the weather is pleasant, but that the temperature is agreeable, neither too hot nor too cold; that there is neither an absolute want of wind, nor gales so violent as to be unpleasant or dangerous. We mean that the conditions of earth, air, and water are such as to make life pleasant and healthy, to make work possible, to promote the growth of useful plants, and to favour the life of domestic animals.

The Climate of England.

It is possible to take a good many views of our own English climate, and to call it good or bad, pleasant or unpleasant. We must all admit that it rains in England rather oftener than some of us would like, that we should be glad to have more sunny days and fewer days of fog and mist. The farmer has often good reason to complain of a season which spoils his hay, or fails to ripen his grain. There is always something to grumble at in respect of our climate, and English people certainly are not behindhand in doing their share of grumbling. Very few of us get through the day without some talk about the Englishman's never-failing subject "the weather." But on the whole there can be no doubt that we are fortunate in

living in a country which enjoys a *temperate* climate, a climate, that is, in which there are no very great extremes of heat and cold, of rain and drought, where work can be carried on at all times of the year, where the winds rarely blow with the force of a hurricane, and where great floods are unknown.

Extremes of Climate.

In many parts of the tropics no white man can work in the fields, and the natives themselves are forced to lie down and sleep at midday when the sun is at its height. In the Arctic regions on the other hand, and in many northern countries the intense cold of winter puts a stop to work of every kind ; while north and south of the 67th parallel of latitude—that is to say north of the Arctic and south of the Antarctic circle—there comes with the winter not only cold and snow, but the long night which lasts for many months.

We in England know nothing of such extremes as these, but it is very easy to see how important a matter climate is, and how necessary it is that we should study the laws which govern its variations.

The Conditions which Affect Climate—Rain.

Let us examine one by one the most important matters which go to make up the climate of a country; let us see why certain conditions exist in one place and not in another, and what is the effect of the climate of a country upon the people who live in it. One of the first things an Englishman thinks of in connection with climate is **rain,** for he has so much experience of it. We shall see, however, farther on, that though we sometimes talk of England as a rainy country, our wettest seasons are dry compared to those which are regularly experienced in some parts of the world.

Before we say anything further about rain, let us clearly

understand what rain is, and why it falls in the way we are so familiar with upon the surface of the earth. Where does the rain come from? From the clouds, of course. But how did it get into the clouds, and, having once got there, why does it fall upon the surface of the earth? If we put a saucer of water upon the table and leave it for a day or two, the water will dry up, as we say. What really happens is that the water passes away in the form of vapour, or **evaporates** into the air. If we put the saucer out of doors or in the sun, we know that the water will dry up or evaporate quicker than if it were indoors.

Evaporation and Condensation.

This same process of **evaporation** which takes place on a small scale in the saucer, is taking place on a much larger scale wherever water is exposed to the heat of the sun. Over every sea, lake, and river, water is being evaporated into the air, and the air becomes charged with water which we cannot see. It may seem strange that water can be contained in the air without our seeing it, but the fact is one with which we are all really familiar. Most of us have at one time or another breathed on a slate to clean it; we know that the surface of the slate becomes moist when our breath touches it. The moisture which we see on the slate was in our breath, and yet if we had breathed into the air of the room we should have seen no trace of the moisture. We have all of us been out on a frosty morning and have seen our breath like steam in the cold air, yet on an ordinary day our breath is not visible.

What is the explanation of this? The explanation is the same in both cases. Our breath at all times contains a certain amount of moisture, but when there is no great difference between the warmth of our breath and the warmth of the air which we breathe, the moisture remains

invisible in the air. When, however, our breath comes in contact with something colder than itself, for instance, the surface of the slate or the cold air on a frosty morning, the moisture is **condensed** and changed from an invisible vapour to fine drops of water which wet the surface of the slate, or which can be seen hanging like steam in the frosty air.

Now we see that it is possible for the water which is evaporated from the surface of the sea or of a lake to be borne in the air without our seeing it, and we have got so far towards understanding how rain is formed. But though we have seen how the water gets into the air we have not yet seen how it is formed into **clouds**, or why it falls again upon the surface of the earth. But if we have followed the examples given above we shall already have formed an explanation for ourselves.

As the invisible vapour in our breath *condenses* on meeting a cold object or a cold current of air, so the invisible vapour which is drawn up by the sun from the earth's surface is turned to water when it comes into contact with something which lowers its temperature. It is this process of *condensation* which forms the thick soft banks of **mist** which we know as clouds. But it is natural to ask how it is that the rising vapours get cooled, and what are the cold objects with which they come in contact. In the first place that part of the atmosphere which lies nearest to the earth is the warmest, and the farther we get from the earth's surface the colder is the temperature of the air. Hence we can readily understand one of the ways in which the rising vapours become chilled and condensed.

Clouds.

Drawn up from the surface of the earth these vapours rise into a colder atmosphere, and are turned into **cloud.** The clouds get swollen and overcharged, and at length dissolve in

drops of rain and fall upon the earth. Often it happens that air charged with vapour drawn up from the sea is borne along until it reaches some mountain range which bars its path. The current of air sweeps it up the mountain sides into higher and colder regions, and the cold tops of the mountains, sometimes capped with snow and ice, quickly condense the vapour into cloud.

Rain in the Lake District.

Wherever, therefore, we find a range of mountains close to the sea, we may expect to find a district where there is a large rainfall. Nor need we go outside our own country for an example. On the north-west coast of England, running from the north side of Morecambe Bay to the Solway Firth, lies the great mass of the Lancashire, Westmorland, and Cumberland mountains. Across the sea the westerly gales blow up from the Atlantic laden with moisture, and as they reach the mountain sides are forced upwards to their chilly tops. Remembering the explanation which has been given above, we should expect to find here a very rainy district, nor should we be disappointed. No sooner has the warm west wind come in contact with the tops of **Black Combe, Helvellyn,** and **Skiddaw,** than heavy clouds begin to form, and the rain begins to descend. In all England there is no place which has so bad a reputation for rainy weather as Seathwaite, in Cumberland, which lies close to the west coast. In a single year this moist little village experienced no less than 217 wet days out of the 365, and what we see in our own country is of course equally true where similar circumstances exist in other countries.

Mountains and Rainfall.

The **Himalayas,** the **Andes,** the **Alps,** all arrest and condense the warm air which strikes against them, and

at those seasons of the year when the warm west wind is blowing, the valleys and the plains below them are drenched in rain. The farther from the mountain chain, the smaller, as a rule, is the rainfall. In the first place, the wind passing over the land picks up less moisture than when passing over the sea, and hence it is that the interior of Australia and of Arabia, both of them flat and dry countries whose centres are distant from the sea, have but a small rainfall. In the second place the inland districts are drier because the clouds which break over the mountain ranges become partly or entirely exhausted before they reach inland country. In England, the east coast, which is low and flat, and which is exposed only to the cold easterly and north-easterly winds, is much drier than the western coast, which receives the warm moist breezes from the Atlantic, and on which are situated the mountain groups of Westmorland, Cumberland, and North and South Wales, and the high moorland of Exmoor.

Wind.

Let us now leave the question of rain and rainfall, and come to another and very important element which affects climate. We are accustomed to speak of the **wind** as something quite unaccountable in its motions, and blowing hither and thither without any fixed law or reason. But though we do not know now all that we hope some day to know about the motions of the winds and their causes, we already know quite enough to enable us to understand a great deal with respect to it. On fête days and gala days, one very often sees small fire-balloons sent up into the air. The balloons are made of thin paper, they are open at the bottom, and a bar across the opening carries a piece of cotton wool which is saturated in spirits of wine and lighted. The flame from the spirit heats the air inside the balloon. Now hot air is lighter than cold air, and as the

air inside the balloon becomes hot it also becomes lighter than the air outside, and consequently the balloon soon floats in the heavier cold air by which it is surrounded. So long as the spirit burns, the air inside the balloon is kept hot, and will float, but as soon as the flame goes out, the balloon will begin to descend, and will shortly fall to the earth. Why is this?

It is partly because whenever two gases of different density come together they have a tendency to combine in such a way as to make a mixture of equal density. Air is an elastic fluid or gas, and when the heavy cold air comes in contact with the light hot air, it immediately rushes in and mixes with it, making **a mixture of equal density.** There is of course far more cold air outside the balloon than hot air inside it, and in consequence, the hot air inside the balloon is soon brought down to a density and temperature nearly the same as those of the air outside. The balloon then begins to fall. Soon the mixture of the air is complete, and the density inside the balloon is exactly the same as the density of the air outside, and the balloon immediately falls to the earth.

This illustration will serve to explain how it is that winds blow in a particular course over the surface of land and sea. There are many parts of the earth's surface which become hotter than other portions of land or sea near them. The air over these parts will receive a portion of the heat of the surface below it and will become lighter or less dense than before. Following the law which has been explained above, the cold air in the neighbourhood will pour in, and in so doing will give rise to a current of air which we call **Wind.**

Temperature of Sea and Land.

There is no space here to give many examples of the movements of the winds, and of the causes of these movements. One or two, however, are necessary in order that

we may understand why it is that the direction of the wind often changes with great regularity at various times in the same place. The water on the earth's surface takes longer to get warm than the land. But having once got warm the water keeps its heat longer than land. Anyone who is fond of bathing has probably had an illustration of this. If we bathe in the sea in May we shall find our bath rather chilly; the water in the sea is colder than the air, and we therefore feel the contrast very sharply when we plunge. The sun has been shining for the same length of time upon both sea and land, but the land has been the first to become warm under its rays. If, however, we bathe again in the month of October, when the days are getting shorter and the nights colder, we shall find that the condition of things has been reversed, and that the sea water is much warmer than it was in May, while the air, except in the sun, is not so warm as the sea. This means that the earth, which first became hot, has begun to get cool sooner than the sea, which took a long time to become warm, but which remains hot longer than the earth.[15]

Sea Breezes and Land Breezes.

Now let us apply what we have learnt to the question of the direction of wind. There are many places, especially in hot countries, where the wind changes regularly twice in every twenty-four hours. During the daytime there is a **sea breeze**—that is, the wind blows in from the sea towards the land. When night falls matters are reversed, and the **land breeze** blows out towards the sea. We have already given an explanation of this alternation in the direction of the wind. During the daytime the hot earth heats the air above it, the air over the earth is hotter than the air over the sea, and the dense cold air rushes in as before to equalise the pressure over the land. At night, the earth, cooling quickly, gives up its heat sooner than the sea. The air over the sea, in

its turn, being warm and less dense than the air over the land, the current of wind is accordingly reversed. Here then, is one illustration out of many which might be given to explain the direction in which the wind blows in different parts of the world, and the causes which set it in motion.

Snow and Ice.

We have spoken of wind, and now we come to another great cause which has much to do with the climate of many parts of the globe. There are very few parts of the world in which **snow** and **ice** are altogether unknown. Within the Arctic circle snow and ice reign supreme all the year round. Within our own temperate latitudes we know them only as occasional visitants, save in those high mountain ranges such as the Alps, the Rocky Mountains, and the Pyrenees, where the peaks are always snow-clad. Even in the tropics, close to the equator, snow is not unknown, and the lofty summit of **Kilima-njaro,** which lies only three degrees from the equator itself, keeps its white crown even under the direct rays of the tropical sun.

A very remarkable example of the effect of snow and ice upon the climate of a country will be found when we come to study what are called the great ocean currents.

Ocean Currents—The Gulf Stream.

If we look at the map we shall see that **Newfoundland, England,** and the southern parts of the Peninsula of **Kamschatka** in Siberia, are all in the same latitude—that is to say, they are all at the same distance, or very nearly so, from the north pole on the one hand, and the equator on the other. But the climate in these three countries differs greatly. Both in Newfoundland and Kamschatka the winter is terribly severe, the rivers, and even the sea, are frozen over for several months, and the ice is of immense thickness.

The mild and open climate of England is unknown, and thick furs have to be worn as a protection against the intense cold. What is the explanation of this difference? It is this. From the **Gulf of Mexico** there flows across the Atlantic Ocean in a north-easterly direction a great stream of water 50 miles broad in its narrowest portion.

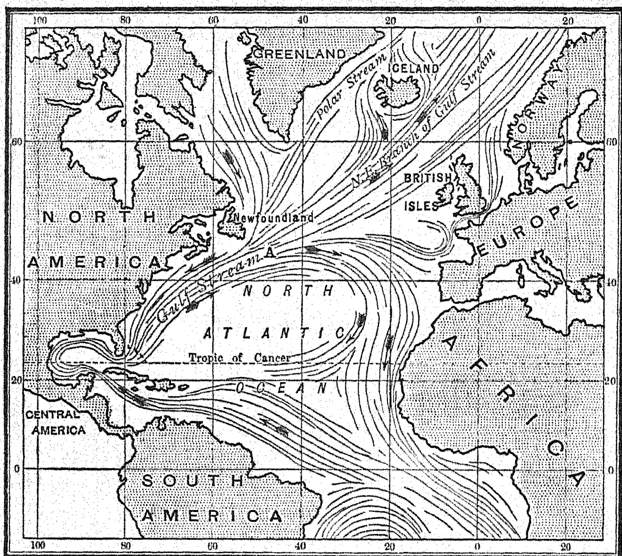


Fig. 43.—The Course of the Gulf Stream.

This stream is known as the "**Gulf Stream**"; and we may see its course marked upon the map (Fig. 43). Entering the Gulf of Mexico from the east it sweeps completely round it, and passes on into the ocean. Under the tropical sun of Central America the water becomes warm. We have already seen (p. 113) that water, though it does not readily become warm, does not quickly become cool again. The Gulf Stream, therefore, having once become hot,

does not become very cool in the long journey across the Atlantic. It may seem strange that hot water should be able to flow through cold water without immediately losing all its heat; but a very simple experiment will show us that this is possible. If we turn on a hot water tap at the top of a bath of cold water we can feel with our hand that the hot water remains for a long time at the point at which it has flowed into the bath, and that the water at the farther end is scarcely affected by it at all. Gradually, it is true, the hot and the cold water will mix, following the same law which caused the mixing of the hot and cold air in the balloon in the experiment described on page 111; but the process will be very much slower. Thus it is that the Gulf Stream, as it sweeps across the Atlantic, bears with it a part of the heat which it acquired in its passage through the Gulf of Mexico.

Course of the Gulf Stream.

In the Gulf of Mexico the temperature of the Gulf Stream is 86 degrees, its breadth is about 60 miles, and it travels at a rate of $3\frac{1}{2}$ miles an hour. At the point in mid-Atlantic marked A in the map, the temperature is 75 degrees, the breadth of the stream is greatly increased, and its speed is diminished. The temperature of the water on each side of the current has been carefully measured and is markedly less than the water of the stream itself. Now follow the course of the current, and you will see that it at last strikes the coast of Europe at the **south-west corner of the British Isles**, and there divides into two branches, one of which passes up the **English Channel** into the **North Sea**, the other up the **west coast of Ireland and Scotland**, washing the **Orkney and Shetland Islands**, and passing also into the **North Sea**. There the northern and southern branches meet, and the united current maintains its course until it reaches the coast of **Norway**, and the **Arctic Zone**.

Effect of the Gulf Stream.

To this warm current we owe to a great extent the moderate and equable climate of England. Deprived of any such assistance, Newfoundland on the one hand, and Kamschatka on the other, feel the full severity of a northern winter. But it may be asked, why does not Newfoundland get the benefit of the Gulf Stream? A glance at the map will show that Newfoundland has the misfortune to lie just north of the current, which washes its southern shore only. Nor is this all. The map shows us another current marked, the "**Polar Stream,**" which flows southward from the Arctic Zone towards the equator. The great glaciers and ice-fields which surround the north pole are always being pushed southwards towards the open sea. In the summer time great pieces of ice are broken off from the ice-fields and glaciers nearest to the sea, and float down along the Polar Stream. These blocks of ice, which are sometimes of enormous size, are met with by sailors in the North Atlantic, and are known as icebergs. And when we remember the fact, which we can easily prove for ourselves, that water when frozen into ice occupies one-ninth more space than in its liquid state, we shall get some idea of the true size of these floating ice-islands. One-ninth only of the mass of ice floats above the water, eight-ninths below it; and an iceberg has been observed and measured, of which the height above the water was no less than 315 feet. From the observation made there must have been under the water a mass 2,520 feet deep. It is calculated that the weight of this iceberg must have been 2,000,000 tons. It will easily be imagined that great masses of ice such as this make the air around them very cold. If we put our hand near a piece of red-hot iron we shall feel a warm glow given off from the heated metal. In the same way a piece of ice will produce the sense of cold, which we can perceive if we put our hand close to the frozen mass.[16]

When a ship sailing in the northern sea approaches an iceberg those on board of her can feel the cold breath of the ice long before they come close to it, and sometimes, in thick weather, before they come in sight of it. Hundreds and thousands of icebergs are carried southwards every year by the Polar Stream, and at length they are brought down to the very edge of the Gulf Stream off the coast of Newfoundland. Here then are two currents, the one hot and the other cold, coming into contact with one another.

The same thing happens that happened when the warm moisture-laden air from the Atlantic came in contact with the cold hill-sides of Westmorland. The moisture in the warm air which accompanies the Gulf Stream is "*condensed*" or turned into mist, which hangs in thick clouds over the surface of the sea. Every sailor who passes the coast of Newfoundland knows this region of mist and moisture; it is the region of the Newfoundland fogs, and is dreaded by all who have to navigate the waters over which its misty curtain extends. For many miles the ships have to pass through the dense fog-banks, and to the danger of collision between two ships is added the still greater danger of collision with the sides of the great floating icebergs. Here, then, we have an example of the way in which ice and snow can affect the climate of a country which is far distant from the spot where the snow falls and the ice is formed. The ocean current which reaches our shores owes its warmth to the sun in the Gulf of Mexico; the current which washes the coast of Newfoundland comes chilled by the snow of the pole, and brings bitter frost in winter, and the thick fog and floating icebergs in the summer. Much more might be said about these ocean currents, for there are many others besides the Gulf Stream and the Polar Stream of which we have spoken. But these two will serve us as illustrations of the rest, which form an interesting and important study in themselves.

SUMMARY.

1. The climate of a country is of great importance to the people who live in it.

2. The climate of a country depends upon a variety of causes.

3. Rain is the result of evaporation and condensation.

4. Clouds formed by evaporation discharge their vapour upon the earth in the form of rain.

5. A cold mountain range condenses the warm clouds which strike against it; hence the heavy rainfall in some mountain districts.

6. The currents of air called wind are the result of movements of the air due to differences of pressure.

7. Water changes its temperature more slowly than land; hence the warmth of the sea in autumn.

8. Sea-breezes are the result of variations of temperature on sea and land.

9. Snow and ice greatly affect the climate of a country.

10. Streams coming from the polar snows chill the countries which they strike.

11. The Gulf Stream, coming from the tropics, warms the countries which it strikes.

12. The climate of the United Kingdom is greatly dependent upon the Gulf Stream.

EXPLANATION OF TERMS.

EVAPORATION.—The conversion of a liquid into vapour, or steam, which passes off into the atmosphere.

CONDENSATION.—The reduction of gas or vapour to a liquid form.

DENSITY.—Closeness, compactness.

CHAPTER X.

THE THERMOMETER.

Temperature.[17]

WE have now spoken of rain, wind, and ice, all of which have a great deal to do with climate. We now have to speak of something which depends to a very great extent upon rain, wind, and ice, and which in some cases is the cause, in others the consequence, of all three, namely **temperature.** The temperature of any part of the earth's surface is its state in respect to the heat which is experienced there. We speak of a high or a low temperature, meaning that the subject of which we speak is either hot or cold. Water at a certain low temperature, as we know, becomes **ice**; at a high temperature it boils and is turned into **steam.** The temperature of the **air** varies very greatly. On the equator it is exceedingly high, at the north pole it is so low that all around is probably snow and ice.

In our own country the temperature, though it varies considerably at different times of the year and at different parts of Great Britain, is never very extreme, that is to say, it is never very hot or very cold. The temperature of a country is the result of many causes, and in the next chapter we propose to speak of some of the principal ones.

Measurement of Temperature.

First of all, however, it is necessary to get some idea of the way in which temperature is **measured.** Unless we do this we shall not be able to *compare* the temperature of one country with another. To say that one place is hotter or colder than another is to tell us very

little; what we want to know is how hot or how cold each place is, and what is the exact difference between the temperature of one place and of another. To measure temperature, we use an instrument called the **Thermometer,** or "*Heat Measurer*";* and mention of the thermometer naturally suggests another instrument which has a somewhat similar name and with which most of us are familiar, namely, the **Barometer,** "*Weight or Pressure Measurer.*" † We shall see farther on that in comparing temperature and in finding out the causes which affect climate in any particular part of the world, it is necessary to know something about the barometer, as well as about the thermometer.

Expansion and Contraction by Heat or Cold.

Almost all substances are affected by heat and cold in a particular way; they either expand or grow larger, or they contract or grow smaller. As a rule, **heat expands, cold contracts.** If the boiler of an engine be filled with cold water until the water just shows in the gauge glass, and the fire be lighted, the water will begin to expand or swell, until, by the time it has begun to boil, it will stand half-way up the gauge glass. The coloured air balls which children buy in the streets to play with often grow slack and flabby when the weather is cold. If, however, we take the flabby ball into a warm room, or hold it before a fire, it will become smooth and round again. The air inside it which had *contracted* with the cold has *expanded* with the heat.

The Whitworth Gauge.

At Sir Joseph Whitworth's great factory at Manchester there is a very beautiful instrument which furnishes us with yet another example of expansion by heat. It is called

* Greek, *thermos*, heat, and *metron*, a measure.
† Greek, *baros*, weight, and *metron*, a measure.

the "**Whitworth Gauge**" (Fig. 44), and consists of two steel points which can be brought together, or moved away from each other by turning a wheel. The arrangement of the wheel is so delicate that the distance between the two points can be increased or diminished by so little as the one-hundred-thousandth part of an inch at a time. To make an experiment we take a solid piece of steel an inch in thickness and place it between the two points of the

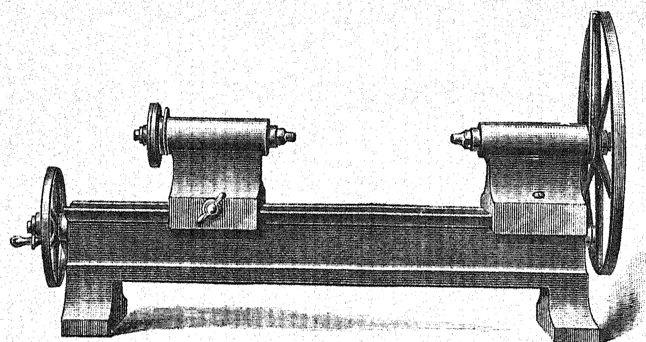


Fig. 44.—The Whitworth Gauge.

machine. We then move the wheel until the points just touch the piece of steel at either end. The steel passes freely up and down between the two points. Now take the steel and hold it for a few moments in your hand, and try the experiment again. This time it sticks and will not pass between the points. What has happened? The same thing has happened that happened before in the case of the water in the boiler, and of the air in the air-ball. The heat of the hand has expanded the steel, and it now occupies more space than it did before. Consequently, it will no longer pass between the two points of the machine. Soon, however, the steel will again fit the space, and will pass through. The air, which is colder than the palm of our hand, *has caused the metal to contract to its former size.* Here,

then, we have examples of the expansion and contraction of water, of air, and of a hard metal such as steel. Let us see how what we have learnt from these experiments helps us to understand the construction and use of the thermometer.

The Thermometer.

A **thermometer** (Fig. 45), is a sealed glass tube enlarged at the lower end, and containing some liquid which fills the enlarged portion, and a part of the tube. The liquid used is not always the same. Sometimes it is air; more often "**alcohol**" or pure spirit of wine is chosen. But the liquid most often used is **mercury** or **quicksilver.** The mercury is placed in the tube, the air is driven out of the part which is not occupied by the mercury by heating it, and the tube is sealed up. Mercury, like every other metal, is affected by heat and cold; it expands when heated, and contracts when cooled. It is easy to see what will happen.

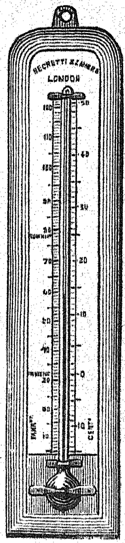


Fig. 45. — The Thermometer.

Suppose that at the time the mercury is put into the tube it fills up the enlarged chamber at the bottom, and stands half-way up the tube. Then directly the air grows hotter the mercury, like the piece of steel in the Whitworth Gauge, will begin to swell. There is, however, only one direction in which it can do so, that is along the empty part of the tube. If, therefore, the thermometer be placed upright the mercury will begin to rise in the tube; and if the heat be considerable will rise so fast that we shall easily notice the movement. If, on the other hand, the mercury become colder instead of hotter, it will contract, and will gradually shrink lower and lower down the tube.

Here, then, is an instrument by which we can at all

times find out a **change of temperature.** If the thermometer be standing in the air and the mercury **rise**, we shall know that the air has become **warmer**; if, on the contrary, the mercury **fall**, we know that the air has become **colder.**

How to Compare Temperatures.

But we want an instrument which will tell us more than this. We want to be able to **compare the temperature** of one place or one substance with the temperature of some other place or substance. A simple plan suggests itself by which we can attain this object. Suppose that as soon as we have observed the height to which the mercury has risen in the tube we put a mark on the tube at the point reached. Then if we take the thermometer to another place, we shall be able to discover at once whether the temperature of the place to which we have taken it be higher or lower than that of the place from which we brought it.

If the temperature be higher the mercury will rise above the mark on the tube; if lower it will fall below it. Here, then, we have an instrument by which we can *compare different temperatures.* But something more even than this is required.

How to Measure Temperatures.

In weighing out tea or sugar we want to know not only whether one packet contains more or less than another, but to know exactly how much each packet contains, whether it be an ounce or a pound or twenty pounds. In the same way we want to be able to **measure** as well as to compare temperatures with our thermometer. It is easy to see what is the first thing to be done. As in weighing tea and sugar we use a fixed weight such as the pound as a *standard* of comparison, so we must get a fixed **standard of comparison** for measuring temperature. How can this be done?

A simple way suggests itself. When we have made our thermometer we have only to mark on the tube a number of equal divisions in order to have a scale on which we can read at once all the movements of the mercury.*

Division of the Scale of a Thermometer.

One more difficulty here presents itself. Where are we to begin and end our scale? It is no use saying that a parcel of sugar weighs ten pounds unless we have an exact idea how much a pound is; and unless the pound weight be exactly the same at all times and in all places we should be quite at a loss when we came to buy and sell by weight.

In the same way with the thermometer. Not only must we divide the tube of the thermometer into equal divisions, but we must know what change of temperature will cause the mercury to rise from one division to another. Unless we know this, it is impossible to *compare* one thermometer with another, for it might happen that a greater change of temperature was required to raise the mercury through a single division in the one than was needed in the other.

Fahrenheit and Centigrade.

In order to avoid such a confusion as this it has been found necessary for scientific men to agree upon some "**standard**" of measurement for thermometers, so that the same change of temperature shall expand the mercury through the same number of divisions in all cases. To do this two things were necessary. In the first place it was necessary that *thermometers should be divided into a similar number of divisions.* In the second place it was necessary that the marking of the divisions should begin and end at

* The expansion of mercury is uniform, or nearly so. There are other substances, however, such as spirit of wine and water, whose rate of expansion is unequal, the rate increasing at high and diminishing at low temperatures. When such substances are used in thermometers the special rate of expansion must be taken into account, and allowed for.

the same place in all thermometers. The first point was not hard to settle. In nearly all thermometers there are either **180** or **100** divisions from the freezing to the boiling point of pure water. A thermometer divided in the former manner is called "**Fahrenheit's**" thermometer, and is the one which is generally used in England. The division into 100 parts is that which is usually adopted on the Continent. A thermometer so divided is called a "**Centigrade**" thermometer—that is to say, one which is divided into 100 grades or steps.* The divisions, whether in Fahrenheit or Centigrade thermometers, are called **degrees.** A degree is written thus: 1°.

The Starting Point of the Scale.

Having settled the number of degrees, we come to the more difficult question, namely, what is the point from which the numbering of the degrees is to start.

It will be seen at once that this is a most important matter. If two thermometers be made at the same time, the one in a hot room and the other in a cold room, the mercury in the two tubes will stand, let us say half-way up the tube in one case, a quarter of the way up it in the other (Fig. 46). If then we are going to make a Centigrade thermometer, the question immediately arises "Where are we to begin to number the degrees from?" Is it to be from the point reached by the mercury? In that case it is plain that the two instruments would be useless for purposes of comparison, for fifty degrees in one would mean something quite different from fifty degrees in the other.

On the other hand, suppose we begin to mark off the degrees from the bottom of the tube we shall be in another difficulty, and for this reason, that the length of the degree would depend entirely upon the length of the tube. A hundred divisions of the long tube

* Latin, *centum*, a hundred, *gradus*, grades or steps.

A would be just double a hundred divisions of the short tube B. It is plain, therefore, that we must have two points at one of which the division must begin, and at the other of which it must end.

In **Fahrenheit's** thermometer, which is divided as described above, 212 degrees is marked upon the tube at the point reached by the mercury when it is placed in **water at the boiling point.** The "**zero**" is fixed thirty-two degrees below the point at which the mercury stands when it is placed in **pure water at the point of freezing.** It is easy to see how this may be done. If the whole scale is to contain 212 degrees and two points in it are known, namely the highest or boiling point, and the freezing point, which is thirty-two degrees above the lowest point, it is clear that between the boiling point and the freezing point there will be **180** degrees. If to those 180 degrees we add on 32 degrees we shall get the whole scale of 212 degrees, and shall also have our starting point or **zero** at 0 degrees and our finishing point at 212 degrees.

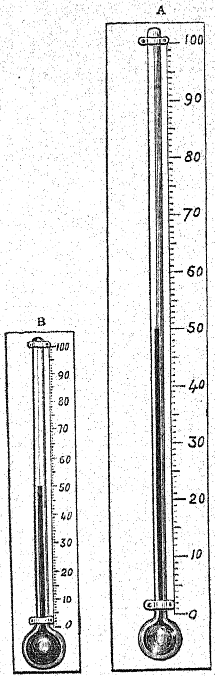


Fig. 46.—Experiment with Two Tubes.

In the **Centigrade** thermometer the same temperatures are used for the fixed points on the scale as in the Fahrenheit thermometer, but the freezing point of water is made the zero point, while the interval between it and the boiling point of water is divided into 100 instead of into 180 degrees. In both Fahrenheit and Centigrade temperatures below **zero** on the scale are marked as "**minus**" quantities. Thus – 7° Fahr. is 39 degrees Fahr.

below freezing point, and 7 degrees below zero. $-3°$ Cent. is 3 degrees Centigrade below freezing point, which, in the Centigrade thermometer, is the same as 3 degrees below zero.*

SUMMARY.

1. Temperature is measured by the thermometer.

2. As a rule, substances expand when heated and contract when cooled.

3. The expansion of liquids by heat and their contraction by cold are made use of in the thermometer to obtain measurements of temperature.

4. The thermometer may be used both to measure and compare temperatures.

5. The thermometers ordinarily in use are Fahrenheit and Centigrade thermometers.

6. The fixed points from which the scale of a thermometer is calculated are:—

(*a*) Freezing point of water.

(*b*) Boiling point of water, taken at a pressure of 29·922 inches.

* It is possible by experiment to find out the exact temperatures known as the temperature of boiling water and that of the freezing point of water. The latter should, strictly speaking, be described as the **melting** point of **ice**, as it is the temperature at which **ice** begins to turn into water. The temperature of the boiling point of water is that of water boiling at a pressure equal to that of 29·922 inches of mercury as indicated by the barometer (*see* p. 136). Pressure varies the boiling point of water; that is to say, a higher temperature is required to make water boil when it is under a high pressure than when it is under a low one. If therefore the pressure were less than 29·922 inches, water would boil at a lower temperature than 212 degrees Fahr. If the pressure were greater than 29·922 inches the temperature required to raise the water to boiling point would be more than 212 degrees Fahr. To avoid, therefore, any irregularity in fixing the scale upon the thermometer, the temperature of boiling water is always taken at the pressure above stated, viz., 29·922 inches.

EXPLANATION OF TERMS.

"MINUS" QUANTITIES ON THERMOMETER SCALE.—The degrees marked below 0°, or zero on the thermometer scale, are spoken of as "minus" degrees. Thus $-5°$ Fahrenheit is 5 degrees below zero on the Fahrenheit scale, or 37 degrees below freezing point.

ATMOSPHERE.—The whole mass of air surrounding the earth.

CHAPTER XI.

THE WEIGHING OF THE EARTH'S ATMOSPHERE.

The Use of the Barometer.[17]

MOST of us have seen a **barometer**, and we have all of us heard of it. We know that by means of the barometer we are enabled to foretell with more or less certainty the kind of weather which we are likely to have during the next twenty-four hours; and we constantly speak of the barometer as **rising** for fine weather, and **falling** for wet weather. It is true that the barometer is of great assistance in forecasting the weather, but, as we shall see, this is not the only or even the principal use of the instrument.

The first use of the barometer is to enable us to **measure the weight (or pressure) of the atmosphere of the earth** at any given place. It is plain that if the use of the barometer be to measure the weight of the earth's atmosphere, we must find out what the earth's atmosphere is, and what effect its weight has upon the surface of the earth, before we can learn how it is measured by the barometer, and what is the use of the measurement when we have obtained it.

The Atmosphere of the Earth.

Our globe is surrounded by a case or envelope of air from 50 to 100 miles thick, and this case or envelope is called the earth's **atmosphere**. This atmosphere has weight, and, like all other bodies which have weight, can be weighed. It may seem strange that air should have any

weight at all. We often say "light as air" to express a thing which has scarcely any weight. But, nevertheless, **air has weight** and can be weighed like sugar or coals, or any solid substance. Moreover if there be a sufficient quantity of air in any place, the weight, as we shall see, will be very great. A very simple experiment can be made to show that air has weight. A pair of scales is arranged in the manner shown in Fig. 47. On one scale is a flask from

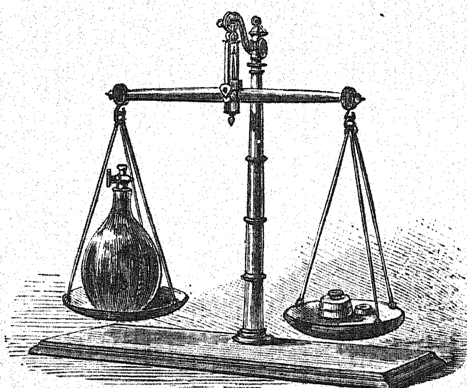


Fig. 47.—Weighing Air.

which all the air has been withdrawn by means of an air-pump. On the other scale is a weight just sufficient to counterbalance the weight of the empty flask.

If the tap be now opened, air will rush in and fill the flask. The balance will no longer remain equal, but the scale to which the flask is attached will sink, showing that *the air has added to the weight of the flask.*

Now we know that air has weight, it is natural to ask how much it weighs. Let us see what a given quantity of air weighs. One of the square tin biscuit boxes with which we are all familiar holds about a cubic foot. If it were filled with water, the water contained in it would weigh 62·3210lb.

If the water be replaced by air, the air would weigh **$1\frac{1}{3}$oz.** A twelfth of a pound is a small weight, but in the atmosphere which surrounds the earth there are many millions of cubic feet of air, and it is therefore easy to see that the weight of the atmosphere must be very great.

As a matter of fact, the weight of the atmosphere upon the surface of the earth at the sea level is equal to a weight of nearly **15 lb.** on every square inch, or **2,160 lb.** on every square foot.

If all parts of the atmosphere pressed downwards with the same force, the weight on a single square inch would be even greater than this. But the weight or pressure of the atmosphere is not the same in all parts of its thickness. On the contrary, the higher we get above the surface of the earth the less it is. The air close to the surface of the earth is pressed down by the weight of the fifty or sixty miles of atmosphere above it, and being thus pressed down becomes **denser** than the air above; that is to say, a greater quantity of it is squeezed or compressed into a given space.

It is easy to understand this fact by the help of a familiar example. A haystack is made up of many loads of hay cut from the same field, and when the hay is first put on the stack, all parts of it will have the same weight or density. If, however, we come a month after the hay has been stacked, we shall find that while the hay at the top of the stack is still light and easy to handle, the hay at the bottom has been crushed into a solid mass which we can only remove by cutting it out with a hay-knife. A cubic foot of hay at the bottom of the stack has much greater density or weight than a cubic foot at the top. The bottom layers have been crushed down by the weight of all the other layers above them. *The nearer the bottom the greater the density; the nearer the top the less the density.* So it is with the earth's atmosphere. The lower part compressed by the part above is denser, and weighs

more than the upper part. The higher we ascend the less the density. This fact helps us to one or two conclusions. In the first place it helps us to understand why the weight or pressure of the atmosphere at the earth's surface is no more than 15 lb. on the square inch. If the air were of the same density from top to bottom of the atmosphere, the weight of a column of air an inch square and sixty miles high would be much more than 15 lb.; but when we remember that the density of the air is greatest at its lowest point, and decreases as we ascend, we shall understand how it is that the column of air weighs only 15 lb.

Already we have made two steps towards understanding the use of the barometer. We have seen what is meant by the atmosphere, and we have learnt that the atmosphere has weight, and that this weight decreases as we ascend from the earth's surface. We have now to inquire by what means the instrument which we call the barometer can be used to weigh the atmosphere in any place.

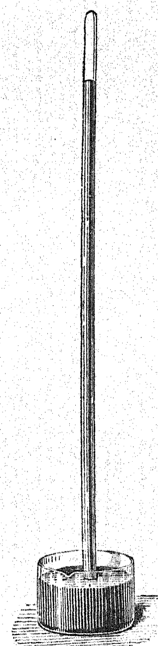


Fig. 48.—The Barometer Tube.

Pressure in Liquids.

To understand this we must first note a very important law which has been proved to be true with respect to liquids. The law is that "**All points in a horizontal layer of a liquid are subject to the same pressure.**" It is not difficult to understand the meaning of this. Let us take as an example a glass vessel full of water—for instance, an "aquarium" such as we see in a drawing-room. The same thing will be true of the water in the aquarium as of the hay in

the haystack. Water we know is a heavy liquid, and all parts of the water in the vessel press downwards by the force of gravity. But in the vessel, as in the haystack, the lower layers of water have to support, not only their own weight, but the weight of all the other layers of water on the top of them. The upper layers press downwards on the lower, and the pressure will of course be greatest at the bottom of the vessel. But though the pressure keeps changing in a downward direction, it is always the same at the same depth in every part of the vessel. In other words, "every part of a horizontal layer is subject to the same pressure." At a depth of one inch from the surface the pressure is the same in all parts of the vessel. At a depth of three inches the pressure is greater than at one inch, but it is the same over the whole layer of water which is three inches from the surface. The same thing is true at five, six, or twelve inches, and at any other depth. What is true of the liquid "**water**" is also true of the liquid "**air**" of which our atmosphere is composed. The pressure varies from top to bottom, but **at equal heights there is equal pressure.** Now we know enough to enable us to understand the law of which we take advantage in using the barometer. It only remains for us to see how the instrument is made and used.

Construction of the Barometer.

A barometer is constructed in the following manner. A glass tube, sealed at one end, about thirty-six inches long, and about a quarter of an inch or more across, is filled with mercury. The tube is then turned over with the sealed end uppermost and the open end dipping into a small trough or basin of mercury (Fig. 48). At first the mercury will begin to run out of the tube and down into the trough; but when it has fallen a short distance it will cease to run out and will remain upright in the tube. If we measure the height of the column of mercury in the tube we shall

find that it is just about **thirty inches** if we are near the level of the sea, and the pressure is the average pressure. What is it that keeps this column of thirty inches of mercury standing upright in the tube? It is the **weight of the atmosphere** pressing upon the mercury in the trough and preventing the mercury in the tube from falling.

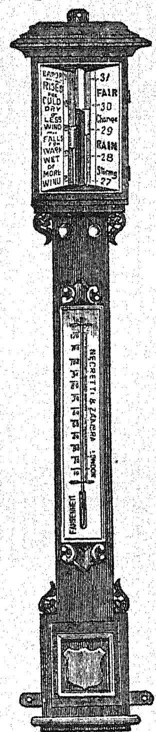


Fig. 49.—A Barometer.

The Weight of the Atmosphere.

But we noticed that at first the mercury *did* run out, and that it was not till the column had fallen to thirty inches that the outflow ceased. What does this fact show us? It shows us that the weight of the atmosphere was not great enough to press more than thirty inches of mercury into the tube, but that it was just sufficient to keep thirty inches in it. In fact, what we have done is *to weigh the atmosphere against the mercury.* We know that if we have equal weights in a pair of scales the balance is equal. Fifteen pounds in one scale will exactly balance fifteen pounds in the other. In our experiment we find that the atmosphere is just heavy enough to balance the mercury in the tube, and to prevent its escaping. A little more mercury upsets the balance. *It is not till the balance is exactly equal that the mercury remains stationary.* But, as we saw just now, if when a pair of scales is equally balanced we know the weight in one scale, we also know the weight in the other. We do not know the weight of the atmosphere, but we can easily find out the weight of the mercury which balances the atmosphere. The weight which keeps the mercury in the tube is exactly the same as

that which keeps the air from entering the tube. It has been found by experiment that *the weight of the atmosphere upon any surface at the level of the sea is, as a rule, equal to the weight of a column of mercury whose base is the same as this surface, and whose height is thirty inches*, or, to be perfectly accurate, 29·922 inches. A column of mercury thirty inches high with a base an inch square contains thirty cubic inches of mercury. A cubic inch of mercury weighs half a pound; the whole column therefore weighs **fifteen pounds**, and thus we see how it is that we are able to discover the fact which we stated just now, that the pressure of the atmosphere is equal to fifteen pounds on the square inch.

Variations in the Weight of the Atmosphere.

We said that the weight of the atmosphere upon any surface is equal, "as a rule," to the weight of a column of mercury whose base is the same as that surface, and whose height is thirty inches. But there are times when the weight of the atmosphere is greater or less than this. It is easy to understand that if the weight of the atmosphere increase, the pressure on the mercury will increase also, and the column will be pushed farther up the tube. If on the other hand the weight of the atmosphere decrease, the pressure on the mercury will decrease also; a smaller quantity of mercury will be sufficient to balance the weight of the atmosphere, and the column in the tube will fall.

Measurement of Height.

We have already seen that under certain circumstances the pressure of the atmosphere *will always decrease*. We saw that the density, and consequently the weight, of the atmosphere grew less as we ascended from the earth's surface. It is plain, therefore, that *the higher we get the less will be the pressure upon the mercury*, and the lower will fall the column in the tube. Here, then, we have one great use for

the barometer, namely, to tell us the **height** of any place on or above the earth's surface, or the depth of any place below it.

At the **sea level**, as we saw, the barometer stands on the average at thirty inches; 1,000 feet above the sea it will have fallen to $28\frac{3}{4}$ inches. At 10,000 feet it will stand at $20\frac{1}{3}$ inches only; while at 29,000 feet, the height of the summit of **Mount Everest**, the column of mercury will rise only to the height of $9\frac{3}{4}$ inches. On the other hand if we go below the surface of the earth, the pressure on the mercury is even greater than it was on the surface, and the barometer will therefore **rise** instead of falling. At a depth of 1,035 feet down the shaft of a mine the barometer stands at just above 31 inches.

But the difference in height above the surface of the earth is not the only circumstance that causes a difference of pressure upon the mercury, and a consequent rise or fall of the barometer. We saw in Chapter IX. that **hot** air was less dense, and in consequence weighed less than **cold** air. Moist air also is lighter than dry air; and consequently the presence of moist or hot air over the barometer will reduce the pressure on the mercury, and will cause the barometer to fall. Hence it is that the instrument is so useful in foretelling a change in the weather. *A change in the density of the air is always followed by a movement in the atmosphere*, and the barometer, as we have seen, tells us of the movement, and warns us of the change by which the movement is sure to be accompanied or followed.

Correction to Sea Level.

It will be seen from what has already been said that before we can **compare** two barometers at different heights above the sea, it will be necessary to make allowance for the difference in the heights. If the barometer at a place in **London**, which is 39 feet above the sea,

stands at twenty-eight inches we say that it has fallen very low, and that some change in the weather, probably a storm, may be expected. But at the top of **Mont Blanc**, 15,000 feet above the sea, the barometer would stand below 17 inches without indicating any such change or disturbance. In order therefore to **compare** the movements of the barometer in two places at different heights above the sea, such as London and the top of Mont Blanc, it is necessary to make an allowance for the difference in the height of the column of mercury which is owing to the height of the place in which it stands. This process of making an allowance is called **"correcting the reading of the barometer to sea level,"** and it must always be gone through before two barometers are compared with one another.

Correction for Temperature.

Another "**correction**" must also be made. Mercury, as we saw in the chapter upon the Thermometer, expands with heat and contracts with cold. The mercury in the barometer is no exception to this rule. There is therefore a rise and fall of the column which is not the result of increased or diminished pressure, but of an increase of heat or cold. In order therefore to compare the effect of the pressure of the atmosphere in two places at different heights and at different temperatures, it is necessary first to correct the reading of the two barometers to the sea level; and then to "**correct for temperature**" by calculating what would be the height of the column of mercury in the respective tubes if they were both exposed to the same temperature. For practical purposes it is usual to calculate the readings of all barometers for purposes of comparison as if they were subject to a temperature of 32° Fahrenheit.[18]

SUMMARY.

1. The barometer is used for measuring the pressure of the earth's atmosphere.

2. The weight of the atmosphere upon the surface of the earth at sea level is equal to 15 lb. on the square inch.

3. The pressure of the atmosphere decreases the higher we get above the surface of the earth.

4. The weight of the atmosphere upon any surface at the level of the sea on the surface of the earth is equal to the weight of a column of mercury whose base is the same as this surface, and whose height is 30 inches.

5. The barometer is used as an instrument for measuring height.

CHAPTER XII.

CLIMATE AND ISOTHERMALS.

Variations of Climate.

Now that we have learnt to use the instruments with which we measure temperature on the one hand and the pressure of the atmosphere on the other, we can return to the question of climate. We can understand what is the connection between climate and temperature, and can inquire what are the causes which make one place on the earth's surface hotter or colder than another. The first and most general rule is this. *Temperature will become higher as we approach the equator, and lower as we approach the poles, thus,*

Lisbon, which is situated in lat. 38° 42′ N., is hotter than **London**, which is in lat. 50° 30′ N. But **London** in its turn is hotter than **Bergen** in lat. 60° 4′ N., or less than thirty degrees from the pole. **Cape Coast Castle**, in lat. 5° 5′ N., is hotter than **Lisbon.** In the southern hemisphere in the same way we find that **Adelaide** (lat. 34° 55′ S.) on the south side of Australia, and therefore far from the equator, is cooler than **Brisbane**, which lies seven degrees farther north (lat. 27° 50′ S.); and **Brisbane** is not so hot as **Pernambuco**, which is in lat. 8° 4′ S.

What is the reason for this rule?

It might seem at first sight as if the explanation were to be found in the fact that the equator is nearer to the sun than the north pole, and that, therefore, the equator receives more heat than the pole. But this is not the reason. The distance from the pole of the earth to the sun is 93,000,000 miles, while the distance from the equator is

only 3,959 miles less. This little distance makes no difference at all as regards the heat of the sun; we must look for another reason to explain the fact. If the nearness to the sun made a difference in the matter of heat we should naturally expect that the tops of mountains, which are nearer the sun than the plains on which they stand, would be warmer than the plains. We know, however, that this is not the case, and that, on the contrary, the higher we ascend the mountain side, the lower the temperature becomes, till we finally reach a height at which snow and ice remain unmelted all the year round.

Absorption of Heat.

The explanation of this is to be found in a fact which it is most important to remember. It is not only from the *direct* rays of the sun that we receive the warmth which we experience upon the earth, but from the surface of the earth which absorbs the sun's heat. The heat which is thus given back from the surface of the earth is said to be **radiated**, and the longer any portion of the earth's surface is exposed to the rays of the sun the more heat will it absorb, and afterwards **radiate** back. The sea, *on the other hand, has a greater power of absorbing the heat, and retains it longer* and continues to radiate more heat after the land which lies near has become cool. And here we have one explanation of the difference of temperature between two places on the earth's surface which lie in the same latitude and which are exposed for the same length of time to the rays of the sun. A place which is situated far from the sea will be very hot in summer and very cold in winter, while in an island such as our own the warmth of the sea is retained throughout the winter, and helps to raise the temperature of the air which flows to the land, and thus we see how it is that the air nearest the surface of the globe is warmer than the air on the mountain tops, or

high above the surface of the earth. *The heat absorbed by the atmosphere is greatest near the surface and diminishes the higher we ascend.*

A Familiar Example.

It may seem strange that the heat of the sun should come to us in this indirect fashion, but we can see an example of the same thing very near home. If a man stand two or three feet in front of a good open coal fire, he will soon find his back become pleasantly warm, and if he stay long enough, he may perhaps find it in time unpleasantly hot. Meanwhile, however, the air between him and the fireplace has not become perceptibly heated at all, indeed it will often be quite cold. The heat which he feels is the heat which is absorbed from the rays as they strike his body. A man's dark trousers or coat will **absorb the rays** of heat with great ease, and will soon become heated, and will begin to give out their heat again, and warm the air in contact with them. In the same way then the sun's rays passing through the atmosphere only begin to warm the air after they have been **absorbed and radiated by the surface of the earth.** And here too, as in our experiment, the nature of the substance on which the rays fall will make a great deal of difference to the amount of heat which is absorbed and radiated. Thus we have already seen that the surface of the earth absorbed the heat quickly and radiated it quickly into the air—in other words, soon lost its heat and became cold.

Polar and Equatorial Temperature.

It is plain that those parts of the earth which are exposed for the longest time in the year to the rays of the sun will, as a rule, be the warmest, for they will receive and radiate most heat. But if the heat of any part of the earth's surface depended only upon the time during which the sun shone upon it, there would be no difference of temperature,

for as a matter of fact, the sun shines for an equal length of time upon all parts of the earth. It is true that in the polar regions there is a long night during which the sun never shines at all, but on the other hand there is an equally long day of perpetual sunshine. On the equator, on the other hand, day and night are each of twelve hours' duration, or nearly so, during the whole year. But we must remember that, though the pole is exposed to the rays of the sun for as long a time as the equator, the rays which reach it have less heating power than those which reach the equator. We shall see the reason of this when we remember that the earth is a globe, and that in consequence the sun's rays strike it at various angles.

Perpendicular and Oblique Rays.

Fig. 50 represents the surface of the earth. A, B, C, D, E are the sun's rays passing through the atmosphere and striking the earth's surface at various angles. Now supposing that every beam brings an equal amount of heat, it is plain that that portion of the earth on which the perpendicular beam A falls will receive more heat than that on which the oblique beams fall. If we look at the drawing (Fig. 50) we shall see at once that the upright or perpendicular beam must bring more heat to the portion of the earth on which it falls than the slanting beams B, C, D, E. For, while all the beams, as represented in the drawing, are the same breadth, the whole of the beam A will be concentrated on the small space of ground numbered 1; the beam B, however, will be spread out over a much larger space marked 2; while C, D, E fall upon the still wider spaces marked 3, 4, and 5—that is to say, the strength of an **oblique** or **slanting** beam will be spread out or diffused over a much larger surface than that affected by the **perpendicular** or **upright** beam. *The more oblique or slanting is the direction of a beam the larger will be the space*

upon which it falls, and the less will be the heat which it brings to any particular portion of the space. Here then is a part of the explanation of the difference in the heating power of the sun's rays at the equator and at the pole. The rays at the equator are perpendicular, the nearer they get to the pole, the greater the angle at which they strike

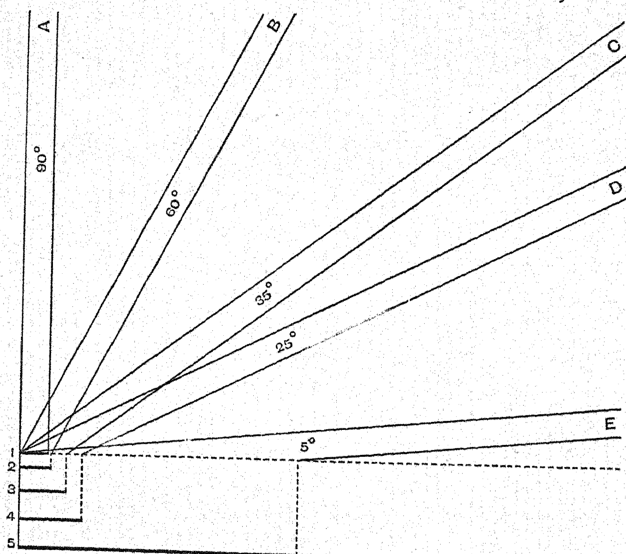


Fig. 50.—Diagram of Perpendicular and Oblique Rays.

the earth. In the figure five beams of light are shown striking the earth at various angles. A which represents a beam falling on the earth at the equator is perpendicular. B strikes the earth at an angle of sixty degrees, but the heat it brings to any one spot is only three-fourths of that brought by A. C falling at an angle of thirty-five degrees brings but half the heat of A. D at an angle of twenty-five degrees brings but one quarter of the heat brought by A; while E falling at an angle of five degrees, and

representing a beam striking on the earth close to the pole, brings but the one-hundred-and-eightieth part of that brought by A upon an equal surface. Thus it will be seen that, unless some other cause come in to affect the temperature, the heat of any part of the earth's surface will depend upon the **latitude** in which it is situated.

The Character of the Earth's Surface as Affecting Climate.

That there are such causes we have already learnt. We saw that the character of the earth's surface often made a difference in the temperature; that the climate in those parts of the globe which were covered with water was less liable to extreme heat or cold than those portions which contained large tracts of land without water. And we saw also that the height of any portion of the earth's surface affected its temperature, and that the higher we got the colder the temperature became.

In Chapter IX. we also saw that **ocean currents, wind, snow,** and **ice** affected temperature, and, remembering all these things, we are able to lay down a general rule for our guidance. The temperature of any place will depend upon its latitude, but an **increase or decrease in height will have nearly the same effect as change of latitude.** Other causes, such as **wind, rain,** the **distribution of land and water and ocean currents, affect climate.**

Altitude and Latitude.

Now that we understand these general rules, let us study a few examples which will make them clear. *Temperature varies according to latitude.* We all know this fact as a matter of common experience. **Penzance** is warmer than **Caithness,** the south of France is warmer than the south of England; and the same thing is true on the other side of the equator. **Queensland** and the northern half of

Australia are very hot, while **Tasmania** on the south side of the island has a temperate and very agreeable climate. These are simple examples of the fact that temperature varies with latitude.

A rise in altitude produces the same effect as a change of latitude.

The hottest place on the earth's surface is probably in the **Sahara** desert in North Africa, which is situated in latitude 15° N. Life is almost unendurable, and the thermometer in the shade rises to 113°. Fifteen degrees nearer the equator is the city of **Quito**, in South America. The equator actually runs through the limits of the city, and yet residents tell us that during the whole of the year, there is not a night on which a fire in the house is not desirable and necessary. But though it is on the equator, the height of Quito is no less than 9,520 feet above the sea, and the great altitude has the same effect in lowering the temperature as we have already seen is produced by change in latitude.

Kilima-njaro.

On the very centre line of Africa, three degrees south from the equator, we find another singular example of a change of altitude producing the same effect as a change of latitude—in other words, temperature decreasing as we rise above the earth's surface, in the same way as it decreases as we go north or south of the equator. In latitude 3° S., longitude 37° 30′ E., stands the great mountain of Kilima-njaro,* the highest known peak of Africa. From its base to within a thousand feet from its summit it is clothed with verdure, but this vegetation varies greatly in its character. At the foot of the mountain are to be found the ordinary tropical plants peculiar to very hot climates—the mango, the acacia, the baobab, the cocoanut. Six thousand feet up the mountain side a pleasant climate is reached, and

* See Johnston's "Kilima-njaro Expedition."

with it is found a new set of trees and plants. The centre has been described as almost exactly like a part of Devonshire, soft and pretty with its hills and combes; many of our familiar English flowers and ferns are to be found there—balsams, the maiden-hair fern, and bracken. With these are mingled bright blossoms never found wild in this country—orchids, begonias, and the great tree-ferns. At 9,000 feet the streams are icy cold, and frost is not unknown, the continuous forest comes to an end and is succeeded by long grass slopes dotted here and there with clumps of trees, like an English park. These slopes, bright with flowers, stretch upwards to the snow line. The flowers cease at 13,000 feet, and the giant heaths which we find lower down are replaced by small plants of the same family, and all the vegetation becomes stunted, and is composed of hardy plants. Above 14,000 feet only a few heaths and everlasting flowers are to be found, and they at last give way to the last representatives of the vegetable world, the little red and green lichens which spread up over the rocks and ridges to the crown of everlasting snow which lies upon the top of the mountain, 18,800 feet above the level of the sea.

"To the ordinary mind, even of an unreflecting traveller," writes Mr. Johnston, the African explorer, "there is something very wonderful and imposing in the aspect presented by such a region as Kilima-njaro. The summit clothed with virgin snow, the upper regions bearing the humble plants of temperate climes—the heath, the hounds'-tongues (to call them by their familiar names), the forget-me-nots, the buttercups, clematises, anemones, violets, and geraniums; the bracken, polypodies, and male fern that are always associated with the flora of our chilly lands; and then, descending through rich forests of tree-ferns, dracænas, and moss-hung mimosas to the vegetable wealth of the equatorial zone, to the wild bananas, palms, orchids, india-rubber creepers, aloes, and the baobabs, which are

among the better known of the myriad forms of vegetation clothing the lower spurs and ramparts of Kilima-njaro."

We have given the foregoing examples to show the truth of what has been said earlier in this chapter, namely, that the effect of the sun's rays, owing to the radiation of heat, is greater on the surface of the earth than at points raised

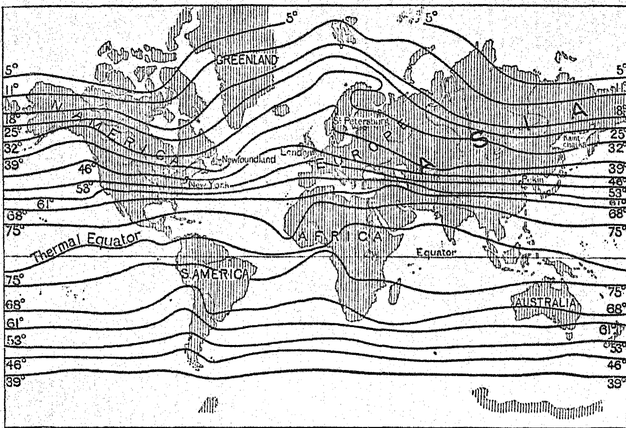


Fig. 51.—Isothermal Lines.

above the surface of the earth. We now come to examples of another kind which will show us that climate and temperature may be affected in other ways than by the amount of sunshine which falls upon the surface of the country. In order to do so we shall have to make ourselves acquainted with a method of observing facts with regard to temperature and climate which has been made great use of by scientific men.

Isothermal Lines.

At the present day there is scarcely any inhabited part of the world where the movements of the thermometer are not

carefully noted from day to day. Thus it has been possible to compare the temperatures of thousands of different places at the same time. One very interesting result has come from these observations. We have already seen that the temperature of two places in the same latitude is very often different; that, for instance, Newfoundland is much colder than England, although it is in the same latitude (50° N.). But the figures which are obtained by observers in many stations enable us to do much more than compare the temperature of the two places.

Fig. 51 shows us a map of the world marked with what are called **Isothermal lines.*** The isothermal lines are lines which are drawn through a number of different places which have the same average temperature. For instance, all places upon the line 5° have an average temperature of 5 degrees, all on the line 11° of 11 degrees, and so on. The course taken by some of these lines is very strange, and can only be accounted for by the facts mentioned in Chapter IX., namely, the influence of warm currents and the sea generally in raising temperature, the effect of wide stretches of land in lowering it, and the influence of winds. The average annual temperature of **Victoria (British Columbia)**, of **New York**, of **Dublin**, of **London**, of **Sebastopol**, and of **Pekin** is the same. But anyone who has visited these places will tell us at once that whatever may be their average temperature all the year round, New York in summer is a much hotter place than London, that the winter in Pekin is far colder than the winter in Dublin, and that no Londoner has an idea of what the ice and snow of the Crimea are really like.

It is quite true that many places which have the same average temperature all the year round have very different

* Greek, *isos*, equal, and *thermos*, heat.

NOTE.—Lines drawn upon a map through places of equal summer temperature are called Isotheral curves (Greek, *isos*, equal, *ther*, summer). Similar lines showing equal winter temperatures are called Isocheimal curves (Greek, *isos*, equal, and *cheima*, winter).

temperatures at the same time of year. The average temperature is obtained by dividing the **sum** of all the temperatures recorded throughout the year by 365. Thus the average of a country like our own, where the thermometer rarely falls very low or rises very high, may easily be the same as that of New York, where the summer heat and the winter cold are both very great. We must bear in mind, therefore, in making use of "Isothermal" lines that something more has to be noticed than the actual average temperatures. We must not only observe what is the temperature taken over the whole year, but what is the temperature taken at any particular period of the year. If we do this we shall find that our lines must be drawn very differently in summer and in winter; for instance, the average winter temperature of London is 36·2°, of Pekin 25·2°, of New York 30·2°, while the summer temperatures of the three places are respectively 62·8°, 81·5°, 74·8°.

Fig. 52 shows us the isothermals in England at different times of the year. A great deal may be learnt by a careful examination of this map, especially if we bear in mind what we read in Chapter IX. as to the different temperatures in land and sea, and the power of the sea to remain warm longer than the land. The first thing which strikes one on looking at the four maps on page 152 is that the isothermals or lines of equal temperature which are there shown make a complete change in their position at the different seasons of the year. Roughly speaking, it may be said that in **January** the lines run from **north to south,** while in **July** they run at right angles to the January lines, in other words from **west to east.**

What does this mean?

It means that in January all the places on the west side of England are warmer than those on the east side, and that it is not the northerly, but the most easterly places which are the coldest. On the other hand, it means that in

summer the farther north we get the colder it becomes, whereas the hottest part of England will be found to be in the south, or rather in the south-east corner round London.

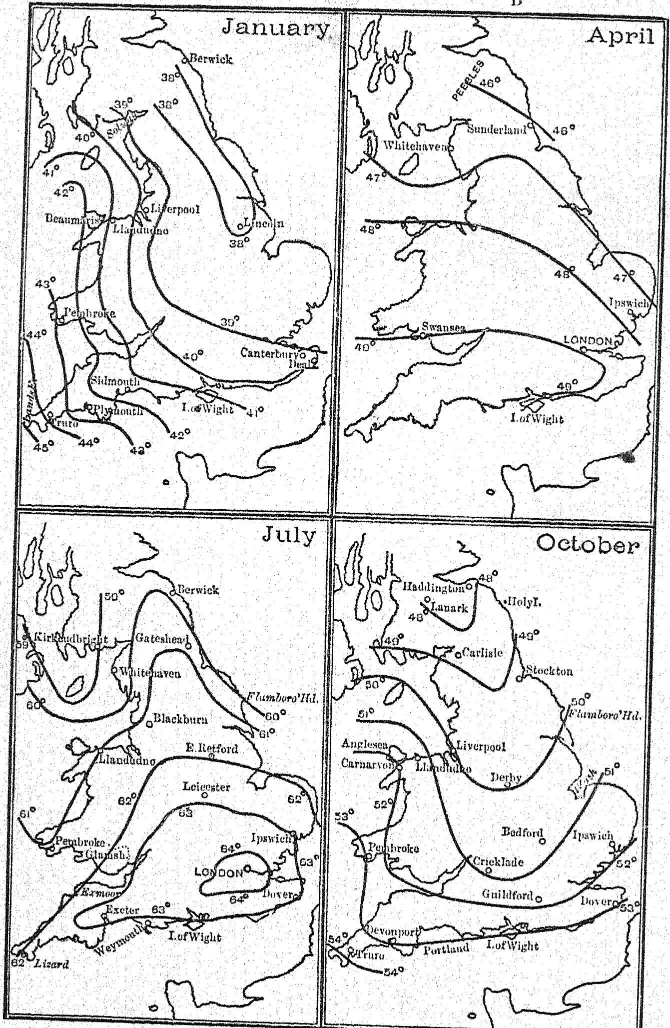
How do we learn these facts from the isothermals in the drawing?

Let us take each season separately, and begin with the plan of the lines as they appear in January. At the top right-hand corner we see a curved line passing down from near **Berwick** to **Lincoln** and running up again to the **Solway Firth.** This line bears the number 38°, which means that the average temperature in the month of January at all the places through which this line passes is 38 degrees Fahr., or six degrees above freezing point. The next line is number 39°, and it passes from the **Solway Firth** in a south-easterly direction through England to **Canterbury.** The isothermal of 40 degrees runs from **Liverpool** to **Deal,** and so we may trace all the other lines numbered 41, 42, 43, 44, and 45. The warmest part of England in January is therefore the portion of Cornwall through which runs the isothermal of 45 degrees. But the one point that the map makes more clear than any other is that the west coast is very much warmer than the east coast, and that a place which is so far north as Liverpool on the west coast is actually warmer than a place like Canterbury, which lies far south close to the German Ocean.

What is the explanation of these facts?

We saw in Chapter IX. that the water of the sea has a great capacity for heat, and that its temperature therefore rises slowly, and in cooling it throws out more heat than the land does, and takes a longer time to cool down to the same temperature. Thus it comes about that, though the sun has been shining throughout the summer with equal power upon the waves of the Atlantic and upon the fields of England, when the winter time comes there is much more heat left in the water than in the land.

A B



C D

Fig. 52.—Isothermals of Ergland at the Four Seasons.

The west winds which blow across the Atlantic reach our western shores and the warm moisture which comes off the sea first strikes our western counties. The result is plainly seen in Fig. 52 (A), showing the isothermals in **January**. Here the west coast appears as the warmest part of our island. But the chill expanse of earth which lies between our western and our eastern coasts has long ago reached a lower temperature, and as the winds and the mists pass over it they gradually lose the warmth which they brought from the Atlantic, and the farther we get from the sea the lower becomes the thermometer, till in the centre and south-east of the country—the points farthest from the Atlantic—it reaches its lowest average.

Now let us look at Fig. 52 (B). It shows us the isothermal lines in the month of **April.** By this time matters have begun to change. The sea is now very little warmer than the land. The isothermal lines, in consequence, begin to shift across the map, but the centre and east still remain colder than the west. **Sunderland,** which is ninety miles south of **Peebles,** is on the same isothermal, that of 46 degrees; but by the time we get down to the line numbered 49° we find **Swansea** and **London** with the same average temperature, showing that the sea now does not raise the temperature of Swansea above that of London, even though the latter be situated inland and not near the sea-coast.

Fig. 52 (C) shows a totally different state of things. The isothermals are at right angles to those shown in Fig. 52 (A). The sun has now been shining for many weeks on both land and sea, but the land, which is more easily warmed than the water, has attained a higher temperature than the sea. The east coast and the west coast are pretty much in the same state as regards temperature; but one thing is remarkable, and will strike the eye at once on looking at the map: the isothermals, instead of dipping down as before towards the centre of England, rise up towards the north.

Gateshead, in Durham, has as high a temperature as **Pembroke**, in South Wales. **Retford**, in Nottingham, is on the same isothermal as the **Lizard**, on the extreme south-west of Cornwall. **Leicester**, in the centre of England, is as warm as the **Isle of Wight**, while around **London** is the hottest part of England.

The explanation is evident.

The land is hotter than the sea, and it is the inland places which are farthest from the sea that are now the hottest; the sea breezes are cool and the land breezes are warm. And now we come to Fig. 52 (D), which shows the isothermal for **October**. Here again the same causes produce the exact results which we should have expected. The land is beginning to cool first. The sea is now much warmer than the land, and in consequence we see the isothermals connecting points almost exactly opposite each other on the Atlantic and on the North Sea, while in the centre of the country they dip far south as they pass through the tracts chilled by the October winds and mists. **Liverpool** and **Flamborough Head** have the same temperature, but the isothermal which passes through them dips as far south as **Derby**. **Anglesea** is as warm as **Guildford**, which lies 150 miles to the south of it, while once more we find that the warmest part of England is in the long promontory of **Cornwall**, washed on both sides by the warm waters of a southern sea.

Thus we see that climate and temperature may depend upon causes remote from the particular country which they affect, and that the warmth of the sun falling upon one part of the earth may furnish heat to shores thousands of miles distant, while the cold of the Arctic snows may bring a chill to lands far south which, by their position on the earth's surface, would seem entitled to warmth and sunshine.

SUMMARY.

1. Temperature as a rule increases as we approach the equator, and decreases as we approach the poles.

2. A large amount of the heat which we receive is not from the direct rays of the sun but from those which are absorbed by the earth.

3. The heating power of perpendicular rays is greater than that of oblique rays.

4. The difference of temperature at the equator and the poles is largely owing to this fact.

5. The character of the earth's surface has a great effect upon climate and temperature.

6. The effect of a change of altitude is nearly the same as that of a change of latitude.

7. Places on the same latitude have often different temperatures.

8. Places having the same average temperatures are said to be on the same isothermal lines.

9. The direction of the isothermal lines varies at different seasons of the year.

EXPLANATION OF TERMS.

RADIATION.—Radiated heat is heat given out from a surface.

ALTITUDE.—Height above the sea level.

ISOTHERMAL LINES.—Imaginary lines on the earth's surface passing through places which have the same average temperature, or the same temperature at any particular time.

ISOTHERAL LINES.—Imaginary lines connecting places which have the same summer temperature.

ISOCHEIMAL LINES.—Imaginary lines connecting places which have the same winter temperature.

CHAPTER XIII.

GEOGRAPHY AND GEOLOGY.

The Crust of the Earth.

WE said in an earlier chapter that a certain knowledge of **geology** was necessary to anyone who wished to study geography to any real advantage. Geology is the knowledge or science of the earth, and deals with the composition and arrangement of the various rocks, clays, and other substances of which the crust of the earth is made up. There is, however, a great deal in the science of geology which, for our purposes, it is not absolutely essential that the student of geography should be acquainted with. It is our object to deal with those facts connected with the earth's surface which in some way or other bear upon the lives of the people who live on the earth, and it is only for this purpose that we refer to geology, and especially to the geology of England. One or two principal facts must be explained before we come to consider the way in which our own, or any other, country is made up. Generally speaking, it may be said that the crust of the earth, as far as we know, is composed of two great classes of rocks—**Igneous Rocks** and **Sedimentary Rocks.**

Igneous Rocks.

Geologists tell us that, in some early period of the world's history, portions of the earth's crust were so hot as to be in a molten or fluid state, and that as they gradually cooled down they hardened into the

rocks which are known in various parts of the world as **Igneous Rocks**, or rocks formed by the action of heat.* Such are **Granite, Basalt, Lava**, and all the other rocks which have been produced by the eruptions of volcanoes; and a great number of others, with the names of which a geologist is bound to make himself acquainted. These rocks are of various ages, some of them very ancient indeed. It is probable that the oldest rocks known to us in this country are Igneous Rocks, or rocks formed by the action of fire: such are the **Granites** and **Porphyries** of Cornwall, and the **Syenite** of the Lizard. The age of these rocks is known to us by the position which they occupy, lying under an immense thickness of other rocks which, we can see from their appearance and position, must have been formed at a later time. Occasionally, however, we find volcanic or igneous rocks cutting through the centre or lying on the top of other rocks, and it is then not always so easy to say what is the date of the igneous, as there is nothing to show at what time the burning lava of which they were composed burst through the rocks above them. The veins of **greenstone** which are to be found in Cornwall and in other parts of the west coast of England, and which are known as "**trap rocks**," are of this nature.

Sedimentary Rocks.

On the top of the igneous rocks comes another great series of rocks which make up a large portion of the earth's crust. These are what are known as the **Stratified** or **Sedimentary Rocks**, rocks which have been formed by the action of water instead of by fire. Everyone is familiar with such rocks as these, and we must all have noticed in quarries or railway cuttings the "**beds**" or "**strata**" in which the stone or gravel which has been exposed to view by the quarrymen is arranged.

* Latin, *igneus*, fiery; from *ignis*, fire.

The word "*stratified*" explains their arrangement, and the word "*sedimentary*" tells us how they were formed. They are in fact the sediment which has fallen to the bottom of standing or running water, and which in the course of ages has hardened into the forms with which we are familiar at the present day. The fact that these sedimentary rocks have been formed at all is plain proof that at one time or another that part of the earth's surface where they are now found was under water, and formed either the bottom of the sea, or of some lake, swamp, or river.*

In course of time the land has risen up or the sea has receded, and what was under water has become dry land. As a rule these sedimentary rocks are found upon the top of the igneous rocks, and from this we learn that they were formed at a later date. This is plain, for the lower rock must have been in existence before the new one could have been deposited upon it. The thickness of the sedimentary rocks which have been deposited upon that part of the earth's surface where England now is, is about twenty miles.

It must not be supposed that the making of the earth's crust has stopped; on the contrary, it is going on all round us at the present day, and from what is taking place under our eyes we can learn what was going on ages ago, when the rocks which we now know were being formed.

The Formation of Stratified Rocks.

It is well to try and understand one or two simple facts with regard to the way in which the earth's crust has been formed, and is still being formed. It is true that such a

* There are also rocks which are known as **Metamorphic**. These are rocks which were in the first instance deposited by water, that is to say, were "Sedimentary" rocks, but which afterwards have become changed, or "metamorphosed" by being brought into close contact with Igneous rocks when in a fluid or molten state. The heat sometimes changes the actual composition of the rock by melting or fusing it, and also removes, to a greater or less extent, the traces of stratification.

study is more nearly connected with geology than with geography; at the same time it is quite impossible to get a real acquaintance with the geography of any country unless we know something of its geological formation. To do this it is necessary to learn one or two important facts, and to make ourselves familiar with a certain number of names and expressions which are used by geologists. A portion of this chapter, therefore, will be given up to a simple explanation of the way in which stratified rocks have been

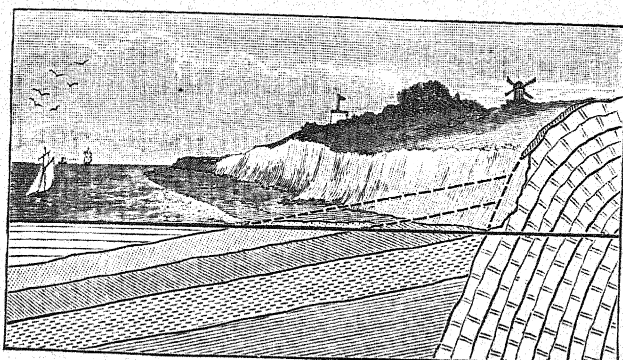


Fig. 53.—Section showing Appearance of Strata after Denudation.

made, and of the causes which have been at work to shape them into their present form.

Let us try and follow the history of a bed of rock through some of the changes which it has undergone. We saw just now that a great part of the earth's crust with which we are familiar is composed of stratified or sedimentary rocks—that is to say, rocks which are arranged in "strata" or beds, and which have been formed by the deposit of sediment contained in water. Here is a picture of an ordinary stratified rock (Fig. 53). The question we have to answer is, how did the rock acquire its present position and its present form?

Let us take a simple case. Fig. 54 represents the bottom of an expanse of water which may be a pond or a lake, or an ocean as we choose to imagine it. Contained in the water is a certain amount of solid matter in the shape of mud, sand, or fine grains of lime. Gradually this solid matter sinks by its own weight to the bottom, and there forms a deposit or **sediment** which in course of time grows thick and closely packed under the pressure from above. The surface of the water is level,

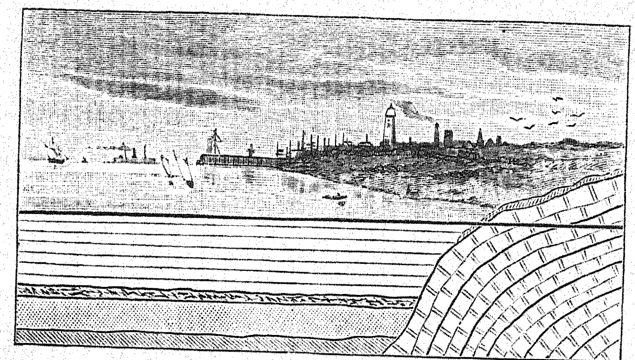


Fig. 54.—Section illustrating Formation of Strata.

and the sediment falling equally on all parts of the bottom, will gradually form a level floor or plain beneath the water. Here then we have a stratified rock in its first stage.

Such a process as that described is going on at this moment in many parts of the world. On a small scale it is going on in every pond and lake, and on a large scale it is going on at the bottom of the Atlantic Ocean, where a deep bed of Ooze is being formed out of the lime which is brought into the sea by the rivers. In the ocean there are millions of minute creatures which absorb the lime and form it into a little internal shell or skeleton round which they grow. These minute creatures are known as "**Foraminifera.**" As

they die the little speck of lime round which they have formed themselves sinks to the bottom and helps to build up the thick stratum of sediment which covers the bottom of the ocean for thousands of square miles. What is going on at the present day has gone on for ages in the world's history, and if we examine the chalk of our southern counties with a microscope, we shall find that its history is exactly that of the **Atlantic Ooze**, and that it is really a solid mass of the same little Foraminifera.

The Tilting of Strata.

But though it is not hard to see how the formation of a stratified rock came about in the first instance, we have not yet found anything which will explain the appearance of the strata in Fig. 53. How was it that the sea bottom became part of the dry land, and how did the level beds become tilted and crumpled as we see them in the drawing? The explanation is to be found in the fact that the *crust of the earth is always in movement;* that from various causes there is a constant alteration going on in the shape and position of the rocks which form it. It is the work of the geologist to inquire into the causes of this movement, and to find out the laws by which it is governed.

Elevation and Depression.

It will be sufficient for our purpose to describe its nature, in order that we may understand its results. There are three great forces at work which tend to change the form and position of different parts of the earth's surface, namely, "**elevation**," or raising up, "**depression**," and "**compression**." These forces have been constantly at work in the past, and are still at work at the present day. Let us inquire shortly into the results which they bring about. The process of **elevation**, or the raising

up of a portion of the earth's surface above the level at which it originally stood, is going on at this present moment in our own country.

An English Example.

There are portions of the English coast which, even within the period recorded by history, have been raised up out of the sea, and have become dry land. In the county of Sussex, a little to the east of Hastings, is a very

Fig. 55.—View of Winchelsea showing Old Sea Bed.

remarkable little town named **Winchelsea** (Fig. 55). A traveller driving from the railway station to the town passes across a flat plain, and suddenly finds himself at the foot of a hill, 100 feet high, up which runs a very steep road. At the top of the hill he passes through an ancient gateway which once formed part of the defences of the place, and he then finds himself within the quaint little town. On the opposite side of the town is another gateway, and another steep hill, from the top of which one looks down upon a broad belt of meadow, and sand, and shingle some two miles across, on the other side of which are seen the waters of the English Channel.

Now Winchelsea has a very remarkable history. In former days it was one of the **Cinque Ports**, which were towns and villages lying on the south-east coast of England, the inhabitants of which received certain privileges from the Crown, on the condition that they furnished the king with a certain number of ships in time of war. Winchelsea in those days was a seaport town, and sent its ships to fight alongside of the ships from Sandwich and Romney, Hastings, Hythe, and Dover. Nay more, Winchelsea was a great trading port. At the present day you can go down into the great vaulted cellars which lie under many of the houses. In the time of Edward III. the town was the centre of a great wine trade with France, and many a cask of claret and burgundy was landed at the Winchelsea quays, and stowed in the Winchelsea cellars. Now, alas, Winchelsea is high and dry; no ship can get within two miles of its old walls, and the water gate leads down, not to the quay, but to a road which runs for two miles across the dry land before it reaches the sea shore.

What has happened to put the old Cinque Port in such an unhappy plight? It has become the victim of a geological change. This part of the coast of Sussex has for a long time been slowly but steadily rising, and the sea, in consequence, has been receding farther and farther. Nor is Winchelsea the only place that has felt the effects of the movement. Out of the five other Cinque Ports mentioned above, both **Sandwich** and **Romney** have shared the fate of Winchelsea, and like it are high and dry inland. Here then is an example within our own country of what was once the bed of the sea becoming dry land. Nor have we far to go to find an example of the **depression** of the land, and the consequent advance of the sea. We have only to go, in fact, as far as the east coast, to the counties of Kent, Essex, Suffolk, and

Norfolk. Thus, from Rainham in Kent to Yarmouth in Norfolk, we find very clear proofs that the sea is gradually gaining upon the land. At **Rainham** the ruins of the old castle are under the sea; at **Dovercourt** in Essex, the stems of what once were forest trees can be seen, at low water only, and at Yarmouth there can still be seen at low water the ruins of an old church which once stood

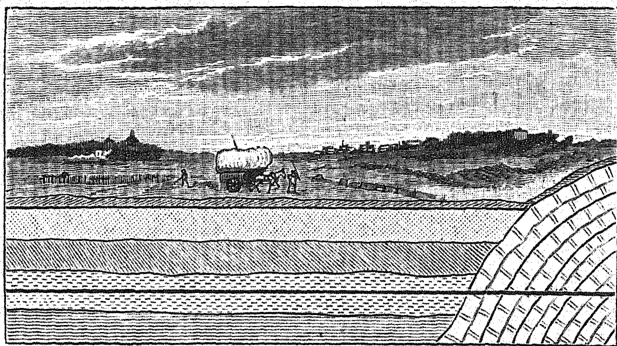


Fig. 56.—Horizontal Strata Raised above the Water.

high and dry on the land, but is now submerged beneath the advancing waves.

Here then we have plain proof that the process of depression is going on under our eyes.

It is easy to understand the effects of these two processes of elevation and depression. The easiest way will be to go back to our diagrams. In Fig. 54 we saw how a level stratum was formed at the bottom of the sea. But now suppose that the bottom of the sea be gradually elevated, and that the water in consequence recede from the place which it formerly covered. Then we shall have a level line of deposit, not as before, at the bottom of the sea, but in the form of solid rock, high and dry above the water (Fig. 56).

Inclined and Crumpled Strata.

Now we have accounted for part of what we see in the drawing, but not for the tilting of the strata. To account for this we must consider what would be the effect of elevation and depression acting together. If, instead of rising equally, the bottom of the sea were to rise

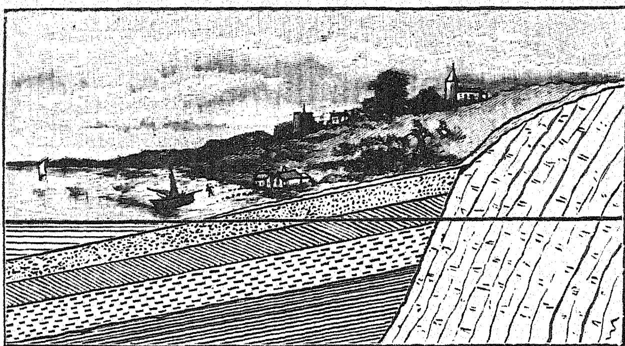


Fig. 57.—Strata Elevated and Inclined.

on one side, and to fall on the other, we should have a result of this kind (Fig. 57). One end of the strata would be raised high above the level of the water, while the other would be deeper below the surface.

Now we have accounted for at least one part of what we see in Fig. 53. We have learnt *how the strata became inclined.* But we have still to find out *how they became crumpled.* And this brings us to the consideration of the other great force we spoke of, namely, the force of compression. If we take half a dozen sheets of paper, and, holding them flat between our two hands, press them together, what will happen? The paper will crumple up. Either it will bend down in the middle and up at the sides (Fig. 58), or it will bend up in the middle and down at the

sides, as in Fig. 59, or else it will bend into a succession of waves up and down, as in Fig. 60.

And in the same way, if the ends of the strata in our example be pressed together, the result will be that they

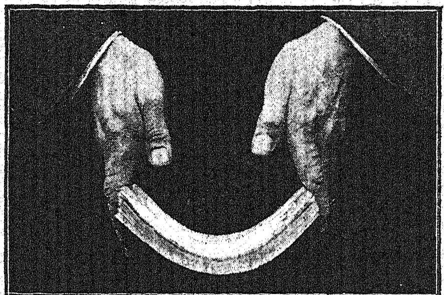


Fig. 58.—Illustration of the Effect of Lateral Pressure.

will be crumpled up in one of the three ways which have been described. In this manner the curving and crumpling which we noticed in the picture are accounted for.

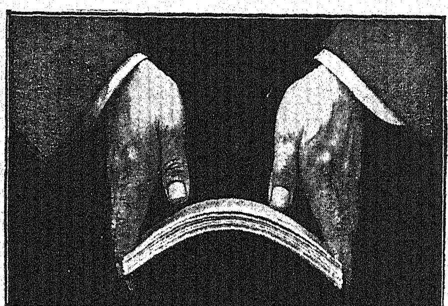


Fig. 59.—Illustration of the Effect of Lateral Pressure.

Denudation.

We have now to consider another process which is at work, and has at all times been at work in shaping and

altering the earth's crust. This is the process known to geologists as **denudation**—in other words, the wearing away, or wearing down of the earth's surface. There are many ways in which it takes place. A simple example may be seen any day at the seaside, when a child has built a castle of sand in the course of the advancing tide. At first the pile of sand stands up a firm and pointed cone. But as the rising ripples reach it, wash round its sides, and

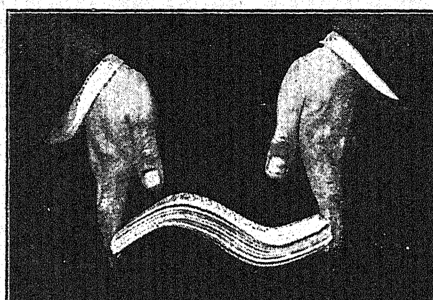


Fig. 60.—Illustration of the Effect of Lateral Pressure.

pass over its summit, its form is gradually softened and smoothed down, till by the time the sea has finally swept over it, it has become only a blunt mound upon the beach. The greater part of it has been **denuded** by the action of the water.

The same action is at work all the world over, wherever the bed of the sea is rising. In the deep water there is little motion, and the power of the waves is unfelt. But, as the strata are raised up into the higher levels where the strong surges beat upon the shore, they are exposed to the same force of denudation which carried away our sand castle on the beach. Let us see the effect of such a process upon the strata which have already furnished us with an example. In Fig. 58 we imagined that the upward

movement of the beds had gone on without any check, and as a result we saw how the sloping strata were formed. But let us suppose that, as the beds rise gradually to the surface of the water, they are swept by the waves. Then, instead of the sloping strata, we shall have the result shown in Fig. 53. That is to say, we shall find a flat surface only just rising above the water in which the various beds will appear as we walk along it. The highest nearest to the sea, then the middle bed, and lastly the lowest. The illustration will show that this must be so.

Here we see the various strata at the point where they come to the surface; and we also see the way in which they slant downwards from the surface. It is owing to the fact that stıata, as a general rule, are *ti ted* or inclined that we see so many kinds of rocks exposed; and that, in going from place to place, we pass from one set of stratified rocks to another. As we saw, the beds, when first formed, are horizontal or flat, and if they were raised up in this horizontal position, only the top bed in the whole series would appear. But when the beds have been tilted and denuded, the edge of each bed appears in turn as it comes up to the surface.

Denudation by Rivers.

There are many other ways in which denudation may take place. Most of us have noticed the manner in which a river, and even a very small stream, bears away the soil and stones from its banks, and gradually levels down the hill side from which it flows. And not only the rivers and streams, but every drop of water that falls upon the surface of the ground, and finds its way down into the sea, helps in the work of denudation by carrying with it some small fragment of solid matter, and thus tending to smooth down the irregular surface of the earth.

Denudation by Frost.

Frost and Ice too are great levellers. All of us who are householders are probably only too familiar with a calamity known as the bursting of the pipes during a sharp frost. The first sign of what has taken place comes with the thaw. The water-pipes begin to leak, walls and ceilings show great stains of damp, and the plumber is sent for in hot haste to set matters straight. What has happened to cause all this discomfort? To understand what has happened we must know something of the property of ice. Just before water reaches the point at which it freezes, or turns into ice, its volume *expands*—in other words, it swells and occupies more space than it did before. A pint of water, as all the world knows, will go into a pint pot, but the same pint of water, after it has become frozen into ice, will not go into a pint pot, but will require a larger vessel to contain it. The exact proportion in which water swells when it turns into ice is one-ninth; that is to say that a given bulk of water will occupy one-ninth more space when it is in the form of ice.

If the ice be formed in an open space such as a pond or a river there will be nothing to prevent its swelling, and it will float to the top of the water and rest there. If, however, the ice be formed in a closed place, where there is no room for it to swell and expand, there will be a different result. The water will follow its usual law, and will begin to swell when it changes into ice. The sides of the vessel which contains it offer a resistance to its expansion, and the ice, in its efforts to increase in bulk, will press violently against the walls which keep it in. The pressure exerted is very great, and only the strongest vessel can resist it. The power of frost can rend the toughest metals, and a small quantity of water collected in the barrel of a cannon has been known to burst it as effectually as an overcharge of gunpowder.

Frost in the Pipes.

It is easy to understand, therefore, how it is that the water in our pipes can prove such an enemy in frosty weather. The frost comes, the water begins to turn to ice, and, at the same time, to swell and press against the sides of the pipe. Before long the pressure against the sides of the pipe becomes greater than the metal

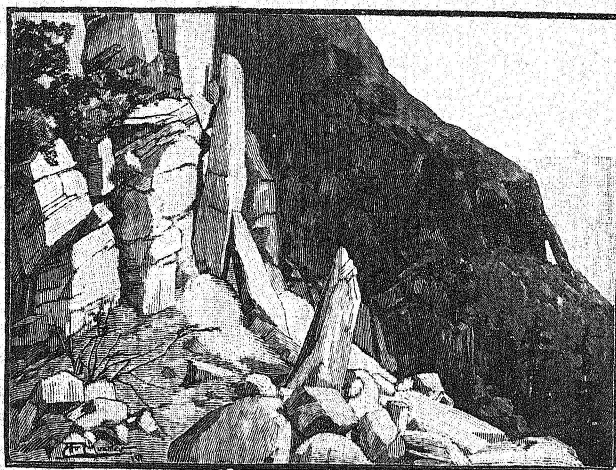


Fig. 61.—Screes.

can bear, and the pipe bursts. As long as the frost "holds" there is no sign of the accident, for the frozen water remains as solid ice in the pipe, but directly the thaw comes, and the water begins to flow once more, the cracks in the leaden tubes betray the mischief, and let loose the unwelcome flood.

Frost on the Mountain Side.

The same force which breaks our water pipes helps to destroy our mountains. The autumn rains or the melting

snows of early winter soak down into the crevices of the rock. Then comes a night of sharp frost. The water, as it freezes, swells in the crevices of the rocks, and, thrusting out in every direction, ends by breaking the walls which confine it, and shivering and splintering the stone. On every mountain side we may see sharp jagged pieces of stone of all sizes which have been split off in this way from the hill side after a hard winter. Year

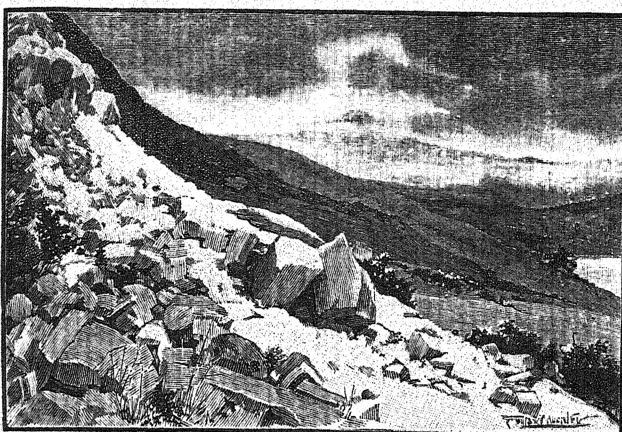


Fig. 62.—Screes on Lower Slopes.

after year the process is repeated, till, little by little, the mountain side is broken away, and the mountain top lowered. In Westmorland and in Wales we may see many examples of the power of denudation exercised by frost. Figs. 61 and 62 represent a mountain side in Westmorland covered with sheets of stone broken off by the action of ice. This broken stone is called *scree* or *screes*, and the same name is applied to the hill sides covered with such stone, so familiar to everyone who has travelled in the Lake Country. It is easy to understand, by looking at the picture, how many

of our mountains have acquired their present shape. In Fig. 61 the process of denudation has only gone a little way, the steep mountain still towers above the pile of scree, and presents an almost insurmountable barrier to the climber. But look now at Fig. 62; you will see in a moment what has happened. The denudation has gone much farther than in the former case. The action of the frost has been continued long enough to have reached the central line or ridge of the mountain; the whole of what was formerly the steep cliff at the top has been denuded by the frost, and has been brought down in fragments to form a long smooth bank of scree.*

It is by such a process that the shape of very many of our mountains has been determined; and in Westmorland, in Wales, and indeed in every hilly country where the denudation has gone on long enough, we find hills and mountains of the peculiar saddle shape which is shown in Fig. 63. The power of frost as a leveller is very great, and must not be overlooked.

Now that we have learnt how it is that strata are formed, how they are raised up and tilted, and how parts of them are laid bare or denuded, it is time to turn our attention to the actual way in which strata which have thus been formed and altered are arranged upon the surface of the earth. This is a subject of much importance, and ought to be clearly understood. Where a bed or stratum lies flat upon the surface of the earth and has not been tilted, its edge will not appear, but when it has been tilted

* The angle at which the stones lie, usually called the "angle of rest," varies according to the nature of the particular rock or soil which forms the scree. Thus chalk has an angle of rest of about 40 degrees, dry sand of 38 degrees, sand of 22 degrees, compact earth of 50 degrees, shingle of 39 degrees, and wet clay of 16 degrees. A knowledge of the angle of rest of different materials is most useful in the construction of railway embankments. The steeper the angle at which stones or earth will lie, the smaller need be the base of the embankment, or the opening of the cutting.

it is plain that only its edge will appear at the surface, while the bed itself slopes down and disappears beneath other beds which lie over it.

Outcrop.

The line along which a bed comes to the surface is called the "**outcrop.**" If we look at any of the figures on

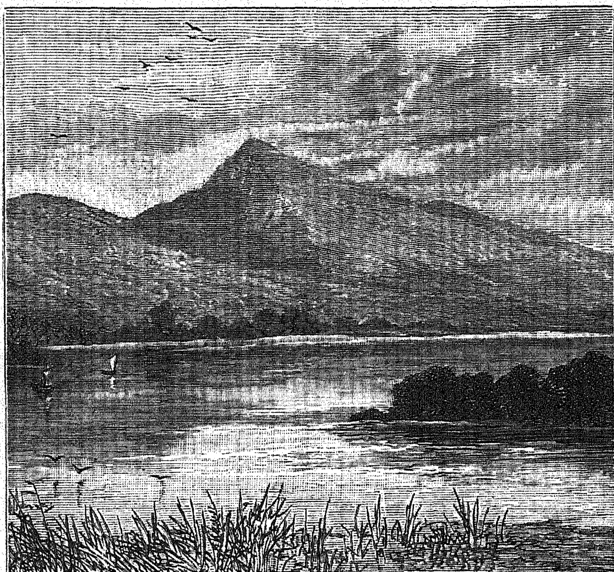


Fig. 63.—A Saddle-shaped Mountain.

pages 185, 186, we shall see the *outcrop* of each bed as it comes to the top of the section. The line of the *outcrop* may follow any direction. It may be straight, or curved, or indented. Its direction will depend upon the surface of the country and the position of the beds.

Dip.

The *Slant* or inclination of a bed is called the **Dip.** A bed slants or "**dips**" downwards from its outcrop. It is often, as we shall see, very important to know the dip of a bed. To describe it properly, we must know two things about it. We must know first in *what direction* the bed slants; and, in the second place, *how much* it slants. The direction of the dip is described by reference to the compass. A bed is said to dip north, south, south-west, or south-east as the case may be. If we stand at the outcrop,

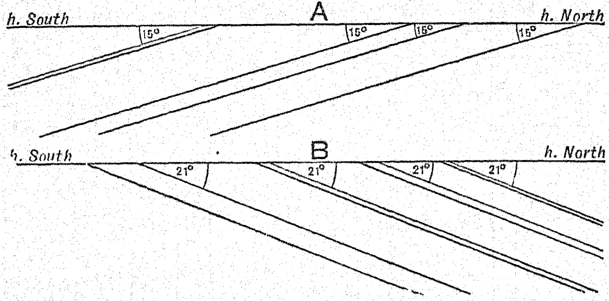


Fig. 64.—Diagrams illustrating "Dip."

and turn our faces to that point towards which the bed dips down from us, we shall be looking in the *direction of the dip.*

To describe the *amount of the dip*, that is to say, to describe the degree of slope in the bed, it is usual to reckon the number of degrees in the angle contained between the line of the dip and the line of the earth's horizon. It is easy to find out what this line is. The bead of air in a spirit level stands in the middle of the instrument when it is on the line of the horizon, or, as we say, when it is perfectly level. The surface of any small pool of water is on the line of the horizon. Thus, if we have two sets of strata A and B (Fig. 64), it will be seen at once that the angle between the horizon *h* and the strata in B is greater than the angle

between the strata in A and the horizon—in other words, that the dip of the strata in B is greater than the dip of the strata in A. If we want to know exactly how much greater the dip is in B than in A, it will be necessary to measure the respective angles. This is done in actual practice by the use of an instrument called the "**Clinometer.**"* In the drawing it would be easier to measure it with a "protractor." In either case we should find that the angle in A was 15 degrees, the angle in B 21 degrees. The strata in A, therefore, are said to dip at an angle of 15 degrees, those in B at an angle of 21 degrees.

But the drawings also show us the **direction of the dip** in the two cases. In A the strata dip from north to south, in B from south to north. The full description, therefore, of the dip in each case would be—A, *strata dipping south* 15 *degrees;* B, *strata dipping north* 21 *degrees.*

Strike.

Lastly, we come to another term, which it is necessary to understand. The term "**strike**" is used to describe the general direction of the "*outcrop*" of a bed or series of beds. It is easy to follow the line of strike in any of the figures on pages 186, 187. It is the direction in which the outcrop runs. It is clear that the "**strike**" **of a bed must always be at right angles to its dip**, for the line of strike is, as it were, the edge of a layer which is tilted at one side. If we take the London Post Office Directory and hold it half open, in the way shown in Fig. 65, we shall see that the edges of the pages with the names printed on them have a strike from A to B, while the pages themselves, which are like the strata, dip downwards in the direction of the arrow. The edge of a page is, of course, at right angles to the page itself; and in the same way the strike of a bed is always at right angles to the dip.

* Greek, *klinō*, I incline, and *metron*, a measure.

The Thickness of Beds.

When we know both the dip and the strike of a bed we can make a very important use of our knowledge; for by a simple calculation we can tell **the thickness of the bed.**

If a series of beds stood straight on end, or in a perpendicular position, as shown in Fig. 66, it would be easy

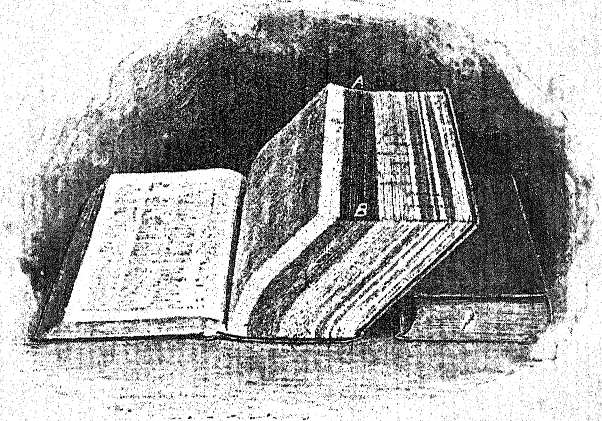


Fig. 65.—An Illustration of Dip, Strike, and Outcrop.

enough to measure the thickness of each bed by walking across from the outcrop of one bed to the outcrop of the next. *The distance between the two points would be the exact thickness of the bed.*

But it does not often happen that beds are found with a perpendicular dip. They usually dip at a much smaller angle than 90°. In Fig. 67 the beds are shown dipping at an angle of 45°. It is plain that if in this case we were to attempt to measure the thickness of the beds merely by walking from the outcrop of one bed to the outcrop of the next, and taking the distance between them to be the

thickness of the bed, we should make a serious mistake. Take a stick and cut it straight through from side to side. We shall get a circular surface of exactly the same diameter as the stick (Fig. 68).

But cut the stick slantwise and we shall get a surface which may be twice as large as the first one. So it is with

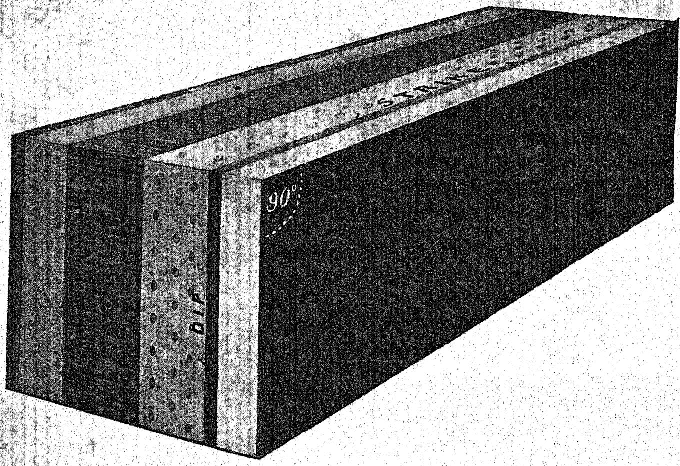


Fig. 66.—Diagram illustrating Perpendicular Dip.

the strata in Fig. 67, the distance between the outcrop of two beds is greater than the thickness of the bed on the tilted edge of which we have been walking. Can we find out how much greater? Certainly we can. Here is a figure (Fig. 69), which represents the problem which has to be worked out.

A and B are the two points of the outcrop. The bed is known to dip in the direction A E and B D at an angle of 45°.

We know the distance from A to B: what we want to know is the distance from B to E, because that is what the

breadth of the outcrop would be if the bed were perpendicular—that is to say, if it stood on end. As we have seen, the breadth of the outcrop of a perpendicular bed is the true thickness of the bed. But it is easy with the facts we now have to tell the length of the line B E, for we already know the length of A B, we know the angle B A E,

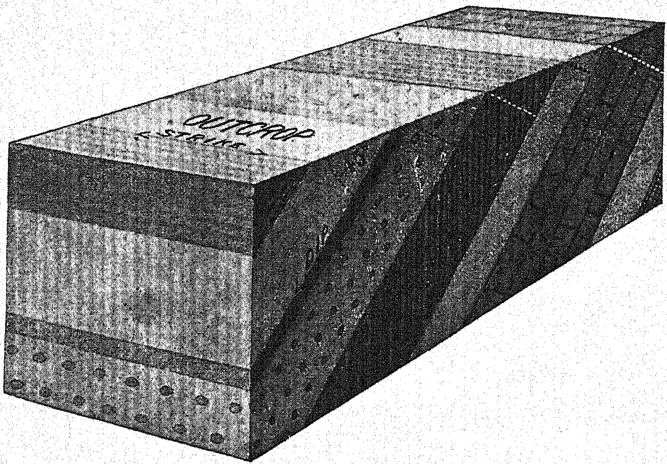


Fig. 67.—Diagram of Beds Dipping at an Angle of 45°.

the angle of the dip, to be 45°, and we know the angle A B E to be 45° also*.

But if we know two angles of a triangle and one side we can draw the triangle. And thus we can draw the

* The three angles A B E, E B D, and D B H = 2 right angles; the line E B is drawn at right angles to B D, therefore E B D is a right angle, or 90°. D B H, the angle of the dip, is an angle of 45° ∴ E B D + D B H = 90 + 45 = 135°.

Two right angles contain 180 degrees. A B E, E B D, and D B H = 2 right angles, or 180 degrees; take from the two right angles the angles E B D and D B H = to 135°. 180 − 135 = 45°, which is the value of the remaining angle A B E ∴ A B E = 45°.—Q. E. D.

triangle A E B. When we have done this nothing remains but to measure or to calculate the length of the side, E B. Directly we know this, we shall know the true thickness of the bed.

It is often of the greatest importance to be able to reckon out the thickness of a bed which has a very slight dip, and consequently a very wide outcrop. For instance, if the beds to be measured contain coal, it is of immense importance to know how thick the whole series of beds really is before beginning to sink a pit.

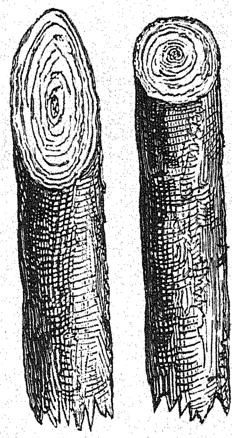


Fig. 68.—Illustration of Breadth of Outcrop.

Curved Strata.

It will be noticed that there are one or two very common forms in the arrangement of strata which are shown in Fig. 70 and Fig. 71. In Fig. 70 the beds form a basin. In Fig. 71

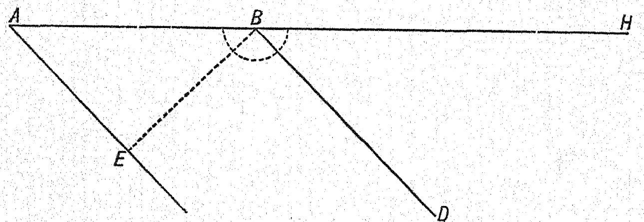


Fig. 69.—Diagram illustrating Measurement of Thickness of Bed.

they are exactly reversed, making an upward instead of a downward curve. The former is called a "**Synclinal**" curve,* which means that the beds are "inclined

* Greek, *syn*, together, and *klinō*, I incline.

together." The latter is called an "**Anticlinal**" curve,* which means that the beds lie or incline away from each other. It is useful to have a clear idea of these two formations, for, as we shall see, a want of such knowledge may

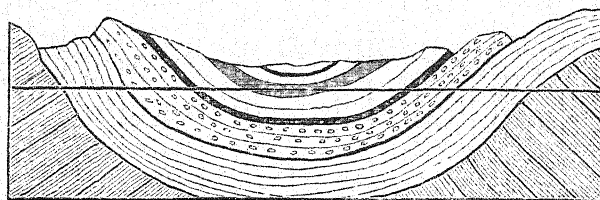


Fig. 70.—Section of a Synclinal.

sometimes lead to very serious mistakes. A simple example will show the truth of this.

Coal and no Coal.

Let us suppose that Fig. 72 shows a section or cutting through an English county. At the point marked A a shaft is sunk, and at 200 feet down the shaft a bed of coal is found. At once we may be sure that a great industry will

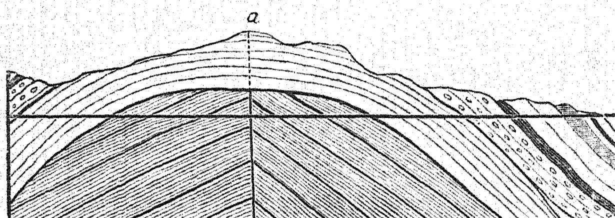


Fig. 71.—Section of an Anticlinal.

grow up, that pits will be opened, and that work on a large scale will be undertaken for the purpose of obtaining the coal. The country side will lose its character of a peaceful plain covered with pastures or corn-fields, and

* Greek, *anti*, over against, opposite, and *klinō*, I incline.

will become the centre of a busy population living among smoke and the roar of machinery. But suppose that an owner of land, hearing of the valuable industry that has sprung up on his neighbour's land, some twelve miles distant from his own property, thinks that he will repeat the experiment, and share the profit. Accordingly, he too drives a shaft 200 feet into the ground at O. But at 200 feet he finds no coal. He sinks deeper, 300, 400, or even 500

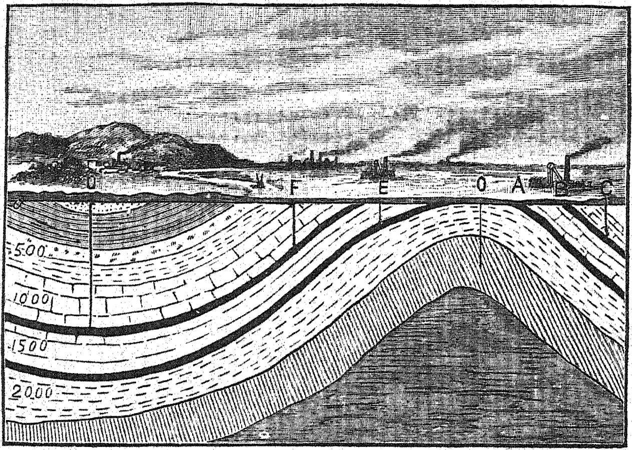


Fig. 72.—Shafts sunk in Anticlinal and Synclinal Beds.

feet. Still the result is the same—no coal. Then at last he calls in a scientific man who has studied the position of the strata, and the scientific man tells him in a moment that all his labour is in vain, for he has been driving his shaft into the centre of an "**Anticlinal.**" The picture will show in a moment how hopeless such an undertaking must be. At A, at B, and at C coal will be found at various depths; but at O no shaft, however deep, will reach a coal bed.

Or again, it may happen that a little farther along the

line of the coal measures, the strata sink into a basin. Then, if a shaft were to be sunk at E or F, coal would be found. At U, in the centre of the basin, a shaft might be driven for hundreds of feet without coming to the coal, and those who drove it might be tempted to give up in despair the attempt to reach the coal measures. If, however they have perseverance, it is clear that at last they will reach the coal. And it would be in the power of an experienced geologist, who knew the arrangement of the country, to tell them at what depth the beds would be found, and thus enable the sinker of the shaft to judge beforehand whether it were worth while to go on with the work.

Viâ Midland Railway.

It is easy to understand what a difference it must make to the people who live upon the surface of the land, whether there be coal at a workable depth below it or not. The most careless observer cannot go through the country without seeing from the clearest possible signs when he has entered upon a coal-producing district. Let us suppose that we are travelling by the Midland Railway from London to Leeds. For many miles the train passes through fields, and hedges, and trees, with here and there a cottage or a village in the distance. It runs through **Bedford, Kettering,** and then through all the quiet country district of **Rutlandshire,** past **Oakham,** and **Melton Mowbray,** till it reaches a point a mile or two north of Nottingham.

Coal and Colliers.

Here everything changes. On either side of the railway are seen the tall chimneys, and the spinning-wheels which draw up the men and the laden coal waggons from the bottom of the pits which lie on either side of the railway. The population becomes dense, and even when the train is

not passing through a large town such as **Sheffield** or **Masborough**, the villages themselves seem to bear the character of small towns, and have no resemblance to the country villages which we passed farther south. Nor is it the outward appearance of the country only that is altered. We shall find that the character of the miners and life led by them differ greatly from the character and mode of life of men engaged in agricultural work. Living close together, and always employed at the same work, the miners naturally form strong societies among themselves, and are able to act together in a way which the labourers in the country can very seldom imitate.

Mountains and Men.

In this respect and in many other ways the life and the habits of men will be affected by the geology of the land upon which they live, and it is singular to note that in almost every part of the world where we find a large population engaged in coal mining, the same peculiar character will be developed among the miners. And in many other ways the geology of a country will have a great effect upon the lives and characters of the people who live in it, and whose habits and occupations depend upon the nature of the soil on which they live.

Summary.

1. Geology deals with the composition and arrangement of the earth's crust.

2. The earth's crust is composed of—

   (*a*) Igneous rocks,
   (*b*) Sedimentary, or stratified rocks.

3. Stratified rocks are usually deposited horizontally, and are inclined by depression, elevation, and compression.

4. Strata are exposed by denudation.

5. Denudation is the work of—
(*a*) the waves,
(*b*) the sea,
(*c*) rivers,
(*d*) rain,
(*e*) frost and ice.

6. The words dip, strike, and outcrop are used in describing the position of stratified rocks, and the direction in which they are inclined.

7. The strike of a bed is at right angles to its dip.

8. If we know the dip and strike of the bed we can tell the thickness of the bed.

9. Curved strata form anticlinal and synclinal curves

10. A knowledge of the arrangement of strata is of the greatest importance to miners.

EXPLANATION OF TERMS.

SEDIMENTARY ROCKS.—Rocks formed by sediment, or matter which has subsided to the bottom of the water.

IGNEOUS ROCKS.—Rocks formed by the action of fire.

TRAP ROCKS.—A term generally applied to igneous rocks which pass through sedimentary rocks or overlie them.

METAMORPHIC ROCKS.—Sedimentary rocks which have been changed, or "Metamorphosed" by the action of fire or heat.

STRATA.—The beds in which sedimentary rocks are arranged.

ELEVATION.—Raising up.

DEPRESSION.—Pressing down.

COMPRESSION.—Pressing, or squeezing together.

DENUDATION.—Stripping off, or making bare.

DENUDATION OF ROCKS.—The stripping or cutting off of the surface of rocks by the action of water, frost, ice, or other means.

DIP.—The inclination, or angle at which strata slope, or dip downwards into the earth.

STRIKE.—The direction in which the edges of the strata run when they come to the surface, at right angles to the dip.

OUTCROP.—The point at which inclined strata crop out, or appear on the surface.

CLINOMETER.—An instrument for measuring the angle of a slope: used for measuring the dip of strata.

PROTRACTOR.—An instrument for measuring angles.

SYNCLINAL.—Inclining, or sloping together.

ANTICLINAL.—Inclining, or sloping in opposite directions.

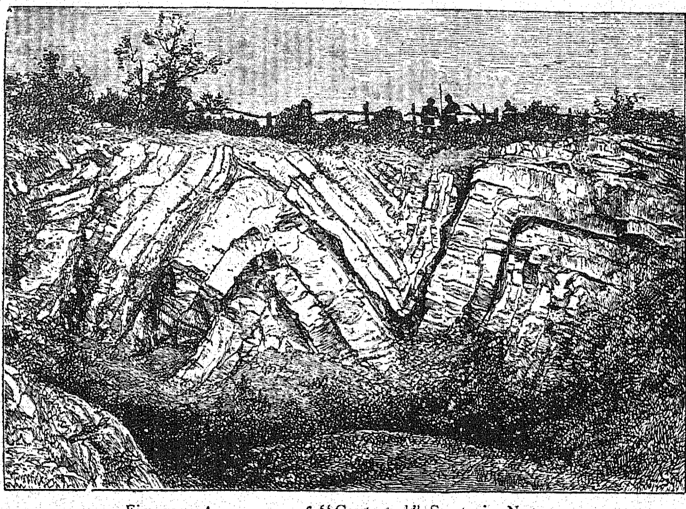
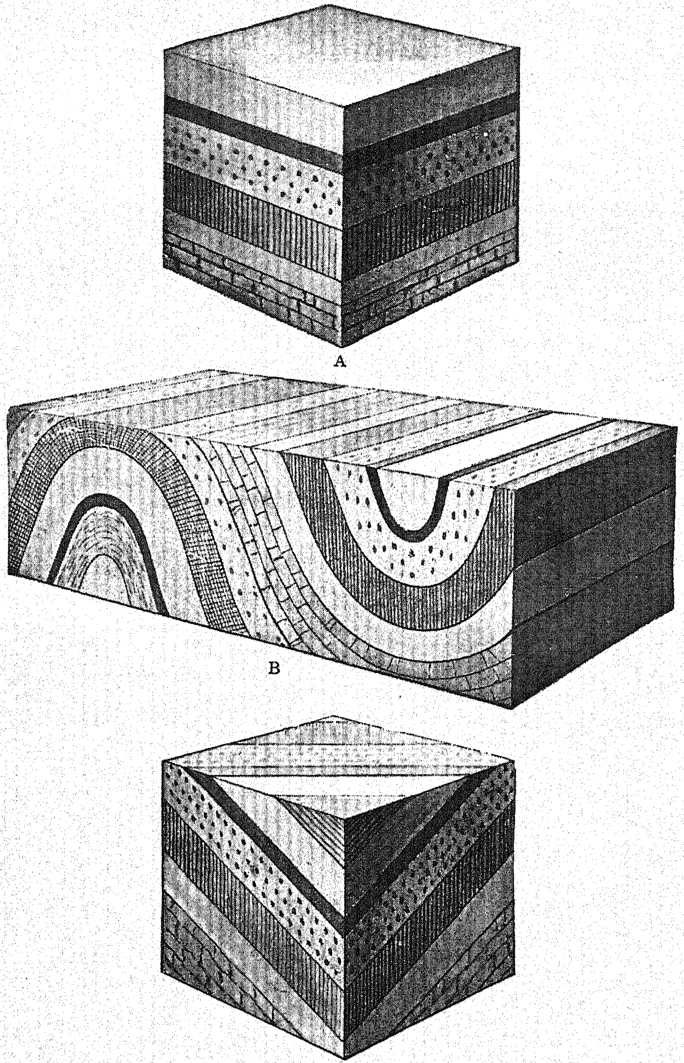


Fig. 73.—Appearance of "Contorted" Strata in Nature.



A

B

C

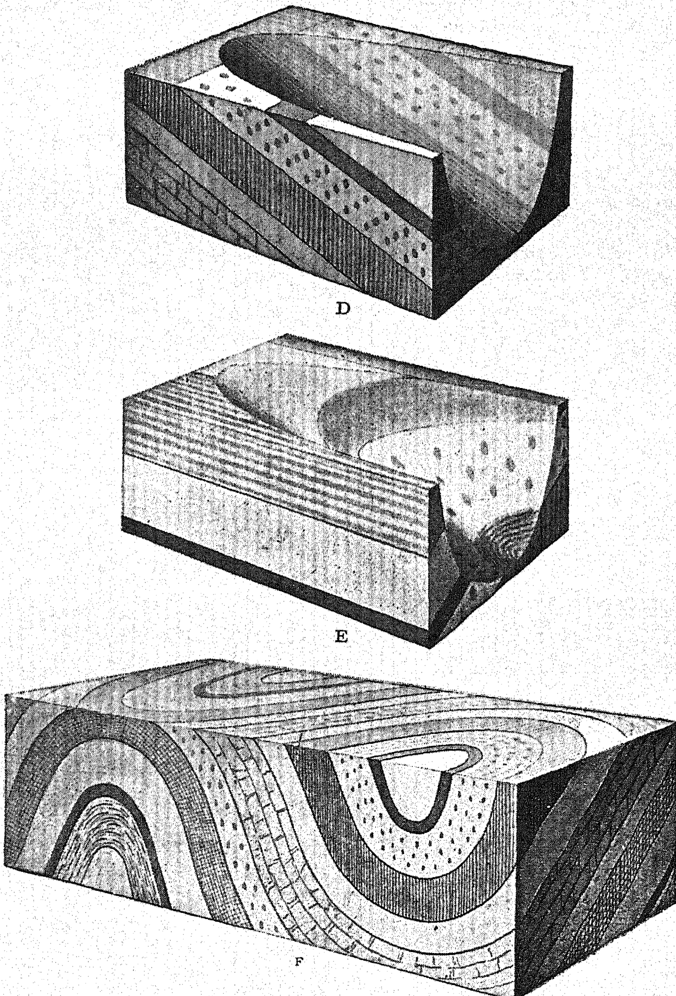


Fig. 74 (A to F).—Diagrams showing Dip, Strike, and Outcrop of Strata at Various Angles of Dip, and with the Section across the Strata at Various Angles in Relation to the Dip.

CHAPTER XIV.

SKETCH OF THE GEOLOGY OF ENGLAND.

Arrangement of English Rocks.

THE first point that strikes one on looking at the Geological Map of England is the regular order in which the strata are for the most part disposed in lines running from north-east to south-west. And if we examine more closely and inquire into the nature and age of the different formations we shall find that, as a general rule, the oldest rocks lie upon the western, and the latest or newest on the eastern side of the island. We have seen that the newest rocks must always be on the top of the older, and thus it is plain that the general "*dip*" of the strata in England must be from north-west to south-east. It must not be supposed that this description is quite exact, and that it will serve to describe the position and dip of all the strata in England; but, generally speaking, the facts are such as have been described.

The Oldest Rocks.

On the west coast we find granite in Cornwall. Throughout the whole of Wales we find either very old igneous rocks, or else the ancient formations known as the "**Primary series**"—the **Lower Silurian** in **Cumberland** and **North Wales**, and the **Cambrian** and **Upper Silurian** rock of **Denbighshire** and **Montgomery**.

Welsh Men and Welsh Mountains.

For the most part these ancient rocks are hard in texture, and their surface is rugged and mountainous. We

have not far to look to find the effect which they produce upon the life of those who live upon them. The rocky valleys and the high peaks of Wales long gave refuge to the Britons when driven back westward by the advancing Saxon. With a poor soil and a damp climate, they gave little opportunity for the increase of agricultural wealth; and the wealth of another kind which they contained was for a long time unknown.

Hence it came about naturally enough that the Welsh, driven back into these mountains, and forced to gain their livelihood in a poor country, acquired, and preserved for hundreds of years, the peculiar qualities of a mountain people. Hardy and independent, they defended themselves with bravery; but without means of communication, they were also without organisation. In time, therefore, they were certain to be subdued by regular forces approaching from the east.

Living among high peaks, isolated, and with little intercourse with the outer world, they developed a character not uncommon among mountain people; and the Welsh bards and the Welsh music were as much an outcome of the rocks and crags of the Silurian formation as the mountain ferns and mosses which cling to the sides of Snowdon and Plinlimmon.

In Cornwall, however, where a kindred British race lived among the granite rocks, in a land at that time almost as inaccessible as Wales, one source of wealth was early discovered, and the tin mines were worked probably in the time of the Romans, and certainly as far back as the reign of King John (1199).

Nowadays Wales has found out that beneath her ancient soil there is also a great store of mineral wealth. Slate for house roofing, and granite for building, not to speak of the gold which has long been known to exist, and which has been actually worked since the days of Queen Elizabeth, in the

valley of Merionethshire ; nor of the great Welsh coal beds of Glamorganshire.

Devonian.

Next in order of age to the **Silurian** rocks, and next in position upon the map, comes the deep band of the red Devonian sandstone. From **Mounts Bay**, in **Cornwall**, the red sandstone stretches north and east through **Devon**, under the **Bristol Channel**, to reappear at **Llandaff** and **Cardiff**. Forming a deep basin under the coal-fields of Glamorganshire, it starts northward again through **Brecon-shire**, where it forms thė two bold peaks of the **Brecon Beacons**, through **Monmouth** and **Hereford**, up to near **Bridgnorth in Shropshire.**

Carboniferous.

Next in point of age to the dark red sandstone of the Devonian comes the great series of **Carboniferous** or coal-bearing rocks. If we draw a curved belt from the eastern side of **Northumberland** ending at **Swansea** on one side, and Bristol on the other, we shall have covered the whole of the Carboniferous districts of England. It must be understood that though the word carboniferous, or coal-bearing, is applied to the whole of this great series of rocks, the actual coal-seams, or beds of coal, are by no means to be found in every part of it.

On the other hand it is true to say that in England it is only in these rocks that any coal is found. Nor must it be supposed that when we speak of a broad belt drawn from **Newcastle** to the **Bristol Channel** including all the carboniferous districts, that every part of the country between those two points is in fact composed of carboniferous rock. On the contrary, you will see from the map (Fig. 75) that the coal-bearing strata appear on the surface like a number of islands in the sea. The fact is, that a very large part of what was once no doubt a

continuous stretch of carboniferous rock has been washed away or *denuded*, but enough is left to show the position which the whole once occupied.

Mountain Limestone.

But there are two or three great divisions in carboniferous rocks with all of which we are very familiar. First of all there is the **mountain limestone**, the light blue stone which forms the Yorkshire dales, and the Yorkshire mountains, **Ingleborough** and **Pen y gent.** A very fine example of the mountain limestone may be seen from the London and North-Western Railway at **Carnforth**, where the rugged hill-side sweeps down to the railway in a succession of steps and terraces, which are almost always to be found in a mountain limestone country. Short bright grass generally grows upon the limestone, and the tree which thrives best upon it is the ash. Some of the most beautiful country scenery in England is in the mountain limestone districts, but it has one draw-back, and that is, that owing to its very porous nature it is often hollowed out into underground fissures and clefts, into which the rivers and streams fall, and continue their course underground. The water, therefore, is sometimes hard to come by in an expedition through a mountain limestone country. On the other hand the limestone is an excellent material for making roads.

Millstone Grit.

There is another great division of the carboniferous rocks with which most north countrymen are familiar. This is the **millstone grit**, which, as you will see on the map, is found in its proper place on the top of the Devonian in North Devon, but of which the greatest stretch is in the north through the counties of **Derbyshire, Yorkshire, Durham,** and **Northumberland.**

The millstone grit gets its name from the fact that it is

truly the stone of which millstones are made, but its chief use is as a building stone. It is rather coarse-grained, and its colour, a yellowish brown, is not very warm or attractive; but it is a thoroughly useful business-like rock, it works easily, and is soft to cut, but hardens well when the "quarry water" is dried out of it, and stands well against the weather.

On the Midland Railway from Derby to Leeds nearly everything you see is millstone grit—the stations, the houses, the town halls, and the churches.

A good example of the difference in the appearance of a country which is caused by a difference in the character of the soil is to be found in those places where the two great divisions of the carboniferous rocks, the mountain limestone and the millstone grit, meet. This may be seen very clearly in running by the Midland Railway from Leeds up the valley of the **Aire** to **Carlisle**, where the line leaves the millstone grit north of **Keighley** and enters the mountain limestone.

Coal Measures.

There is one other important division of the carboniferous rocks known as the **coal measures**, chiefly composed of sandstone, in which the greater part of the actual coal is found. On the map (Fig. 75), you will see these black patches. A large one is seen in **South Wales** where the Welsh coal-field is surrounded by a thin band, first of millstone grit, and then of carboniferous or mountain limestone. Other patches are to be seen in the midlands and farther north, and contain the coal districts of **Warwickshire, Lancashire, South Yorkshire, Derbyshire,** and some other districts. We shall have something more to say about these islands of carboniferous rock and of the coal which they contain, for a great part of the prosperity of England is owing to the number and extent of these patches.

Permian.

As the carboniferous rocks are later in time than the old red sandstone, they will everywhere be found *above* the rocks of that formation, and these in their turn will be below

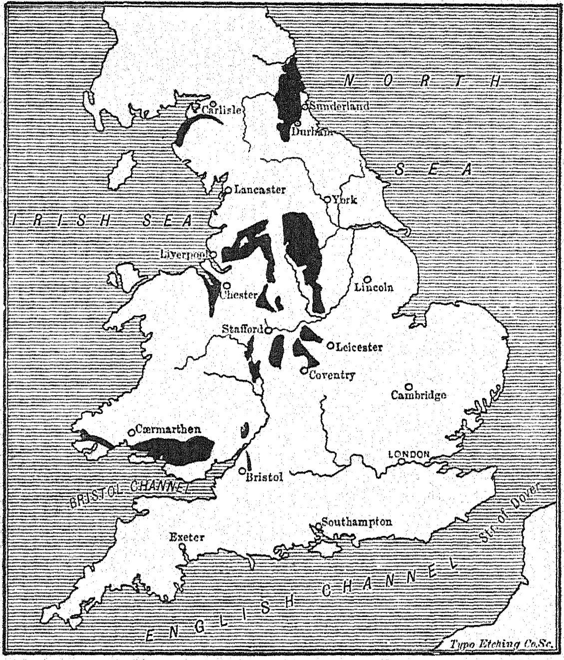


Fig. 75.—The Coal Districts of England.

the **Permian** or lower red sandstone beds which, as you will see, appear along the edge of the carboniferous rocks in Durham and Yorkshire.

Trias.

Above the Permian comes another set of rocks known as the **Trias**, which includes a great stretch of the **New Red**

Sandstone, and extends all the way from the south coast of **Devonshire**, through **Somersetshire**, **Warwickshire**, **Derbyshire**, **Cheshire**, **Nottingham**, and **Yorkshire**, till it comes out in the sea again at **Hartlepool** in Durham. It is of this new red sandstone that the rather crumbling towers and walls of **Chester** Cathedral are built, and anybody who has travelled down to Liverpool by the London and North-Western Railway will have seen long stretches of the new red sandstone in the deep cuttings at **Olive Mount**.

It is in the new red sandstone in Cheshire that the great **salt beds**, which supply the brine springs of Northwich and Droitwich, are found. The line of the **Manchester Ship Canal** from Manchester to the point where it runs into the Mersey at **Eastham** is cut entirely through new red sandstone, and the sandstone itself is used for making the sides of the canal.

Salt Beds.

The salt which is found in such great quantities in the new red sandstone is of very great value. But like many other advantages, it also has its drawbacks. The salt is obtained by pumping out the water which has filtered down in the rock through the beds of *chloride of sodium* which are contained in it. This water, impregnated with salt and known as brine, is then evaporated and the pure salt is left behind.

But the effect of pumping out many millions of gallons of water over a large area is to undermine the surface of the ground in many places. Hence, throughout the whole of the salt region of Cheshire, subsidences of the ground are very common. In **Droitwich** the streets rise and fall like the waves of the sea, and occasionally, houses, or even streets, collapse without warning as the earth on which they stand falls into the hollows made by withdrawing the brine and the salt which is contained in it.

An Unlucky Well.

Sometimes, too, the red sandstone gives trouble in other ways. An instance occurred near Rugby not many years ago which furnishes us with a capital example of the value of some knowledge of geology. A fresh supply of water was required for the town, and it was decided to bore a well in a spot about half a mile distant. It was believed that water would be found at a depth of about 300 feet. The boring was made to the required depth, but no water appeared, and it was decided to continue the shaft. The work went on: 500, 600, 700 feet were cut through by the drill, and still there was no water. At length at a depth of 1,300 feet the patience of the borers was rewarded. A strong rush of water rose up to within 300 feet of the shaft, and nothing apparently remained but to pump it to the surface. The water was bright, clear, and abundant, but it had one fault which appeared as soon as it was tasted. It was the strongest brine. The drill had cut down to the new red sandstone beds which, sloping gently from the north-west, underlie the whole thickness of the oolite, and the water which had been obtained had filtered through the red sandstone and had become salt in doing so.

Lias and Oolite.

Once more we shall find our rule about the position of the different stratified rocks in England becomes true, for next in order of time to the new red sandstone come the great formations known as the **Lias** and the **Oolite.** As they are next in age to the red sandstone so also they are next in position, lying in a broad strip across England from **Lyme Regis** on the south-west to **Whitby** on the north east.

There are a great number of small divisions in the lias and oolite, but they are chiefly composed of *limestone* rocks of different kinds, the beds of which are in many cases divided by thin layers of *shale* or *clay*. The whole of this

series is wonderfully full of fossils ; some of the beds indeed being made up almost entirely of fossil shells, while the oolite gets its name from the fact that it is made up of the remains of innumerable little shells which are supposed to give it the appearance of the roe or eggs of a fish.*

The oolites are used for a great number of different purposes, and many qualities of building stone, some good and some very bad, are cut from them. A great deal of very inferior stone, known as the **Oxford Rag**, was used at one time in building some of the Oxford colleges, and the result has been that many of the walls have fallen to decay and have had to be replaced by better materials.

On the other hand, some of the very best building stone we have, the well-known **Bath Stone**, is cut from the oolite beds in and around Bath, and the well-known **Portland Cement** also comes from lime quarried from the oolite beds.

Fine examples of the lias may be seen on the Midland Railway near **Barrow** in Leicestershire, where the alternate strips of clay and limestone are very well marked. The **Blue Lias**, as it is here called, is quarried in many places for lime burning. And here we may mention how important a thing lime is, and how much men are dependent upon it.

The Value of Lime.

Only those who are acquainted with parts of England where there is no limestone rock can understand how valuable limestone is, and for what a variety of purposes it is required. Thus in **Pembrokeshire**, where the rock is for the most part *metamorphic* (*see* p. 158), there is no lime to be got on the spot, and every ton of lime which is used, either for the purpose of making mortar, or for putting upon the land for the benefit of the crops, has to be brought by sea, and such is the case in other parts of England. Here,

* Greek, *ōon*, an egg, and *lithos*, a stone.

then, is another practical instance of the value of some knowledge of geology in our daily life.

The Chalk.

But to go back to the order in which our English formations are arranged.

Now once more we come to a newer formation and once more we find it towards the east. This is the great series of rocks which contains the **Chalk**, and other beds which you will see marked on the map as the **Weald**, the **Greensand**, and the **Gault**.

Everybody knows the appearance of the white chalk formation at Dover cliffs; or where the various railways have their cuttings through it—the Great Western Railway at **Wallingford**, and North-Western at **Tring**, the South-Western on **Salisbury Plain**, the Great Northern at **Hitchin.** There are two great divisions of the chalk known as the **upper and lower chalk.** The latter is full of **flints,** and throughout the lower chalk country we see everywhere churches, houses, and walls, built of the flints. The Greensand, the Gault, and the Wealden Clay which forms the centre of **Kent** and **Sussex,** are not so clearly marked in their appearance as the chalk itself, but they form part of the same series, and as you will see on the map the Greensand fringes the chalk for nearly the whole of its length, the chalk lying on the top of the Greensand.

The Downs.

The great line of **Chalk Downs** which runs from **Beachy Head** across Sussex and turns northward near **Salisbury**, circling almost entirely round London, has a special importance, for the Downs are marked out by military men as forming the line on which, if ever we were called upon to defend London from an enemy, a battle would probably be fought. So plain is this that the Government have already made

plans for defending the line of the chalk Downs to the south and west of London.

The London Clay.

We have now nearly come to the end of the different formations, but we have still to consider those which are marked Nos. 3, 2, and 1 upon the map. These are the newest formations of all, and, according to our rule, we find them lying on the extreme east of the country. No. 3 is the **London Clay** upon which London stands. You will get an idea of the character of London clay if you take a ticket from Paddington to Reading by the Great Western Railway. Between **Acton** and **Reading** the train passes through endless brick-fields, and the strong smell of the burnt clay fills the carriages as the train passes. This is London clay being formed into those bricks of which we see so many miles piled one upon another in the ugly streets of London.

The Newest Formations.

The portions of the map which are numbered 2 and 1 are still newer than the London clay. They are composed for the most part of **Gravel** and **Drift**, some of which has actually been formed or left bare by the sea within the period recorded by history. If we take the train from **Dover** to **Ramsgate** we shall, shortly after leaving **Deal**, pass through a small plain lying near the sea in the midst of which is the little, but ancient, town of **Sandwich**. The plain is known as **Sandwich Flat**, and the narrow winding stream which runs through it is **Sandwich Haven**. Sandwich, like Winchelsea, of which we spoke in an earlier chapter, is one of the *Cinque Ports*—that is to say, it is one of the five towns which, in return for certain special privileges, were bound to send ships to serve the king in time of war. But the days of Sandwich as a seaport are long past. It cannot now furnish any ships for the Queen's navy, for it is two miles inland high and dry in the midst of green fields. What has happened is that the

coast in the neighbourhood has been gradually rising, and Sandwich Flat is really made up of soil which has been left there by the sea long since the time of the landing of the Romans.

There are other formations of this kind on parts of the east coast, and these appear on the map in the places marked with the figure 1.

We have now gone very quickly through the various formations of which England is built up.

This chapter is not intended to be in any way a complete description of the geology of England, but the list which we have given will be sufficient to show how much variety there is in the character and in the history of the soil upon which we live. Some of the examples which have been given will also help us to understand how great a difference the nature of the soil and the arrangement of the rocks makes to those who live upon the earth's surface.

Summary.

1. As a general rule the dip of English rocks is from N.W. to S.E.

2. The oldest rocks are found on the west coast, the newest on the east

3. The principal divisions of English stratified rocks are—

(*a*) Cambrian,
(*b*) Silurian—lower and upper,
(*c*) Devonian, and old red sandstone,
(*d*) Carboniferous, including mountain limestone, millstone grit, and coal measures,
(*e*) Permian,
(*f*) Trias, or new red sandstone,
(*g*) Lias and Oolite,
(*h*) Chalk, including Greensand, Wealden, Gault,
(*i*) Tertiary.

CHAPTER XV.

RIVERS.

The Course of a River.

In the last two chapters we have spoken of the formation of the crust of the earth. We are now about to deal with some of the forces which operate upon the surface of the earth's crust and which help to shape or to modify its character. Among the most important of these forces we come to the great force exercised by running water and the power of rivers.

Every mile in the course of a great river, from its source to the sea, is a subject worthy of study, and full of instruction.

Rivers.

To every class a river has its special interest. The geologist sees in its water a ceaseless force levelling the mountains with the valleys. To the merchant the river is a silent highway along which he despatches his goods; to the traveller it is a sure guide through unknown lands, a clue which will lead him with unfailing certainty, down to the sea. To the manufacturer it is a source of power to turn his mill-wheel. The soldier sees in it a defence or an obstacle in war. The patriot fights to defend "*The German Rhine;*" the poet sings of "*Father Thames,*" and "*Father Tiber.*" The native of Bengal entrusts the body of his dying parent to the sacred waters of the *Ganges.* The Egyptian depends for his existence upon the bounty of the fertilising *Nile.* In all times, and in all places, rivers have played a great part in the history of mankind.

We propose, therefore, to give up two or three chapters to discussing some of the most important facts connected with rivers which specially concern a geographer.

In order to get a true idea of the geography of a country, it is necessary to make a careful study of the rivers which it contains, to note the direction in which they run, and to find out what portions of the country are drained by each river.

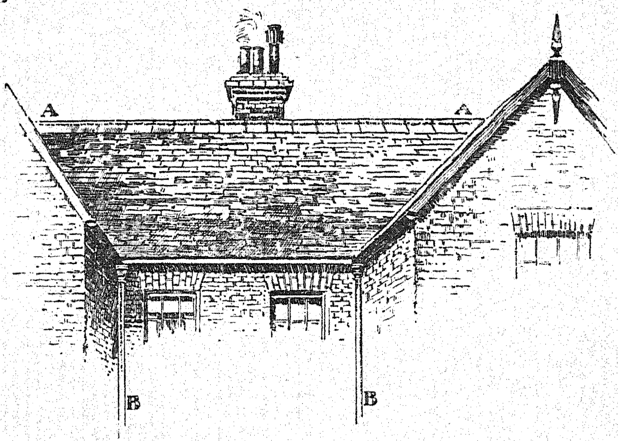


Fig. 76.—A Domestic Watershed.

The first thing to be noted is the position and character of the principal **watersheds.**

A Watershed.

A watershed* is the line of parting between the head waters of two streams, or sets of streams. A simple illustration will serve to make the meaning of the term quite clear. Fig. 76 shows the roof of a house with a ridge tile, A A, running along the top of it. When rain falls on the roof it runs down one side or the other into the water-pipes

* Shed or "Sched" means to part or divide.

which carry it away. All the rain which falls on one side of the ridge tile will run into the pipes B B, all that falls on the other side will run into the pipes on that side. The ridge-tile therefore represents the watershed, or water-parting

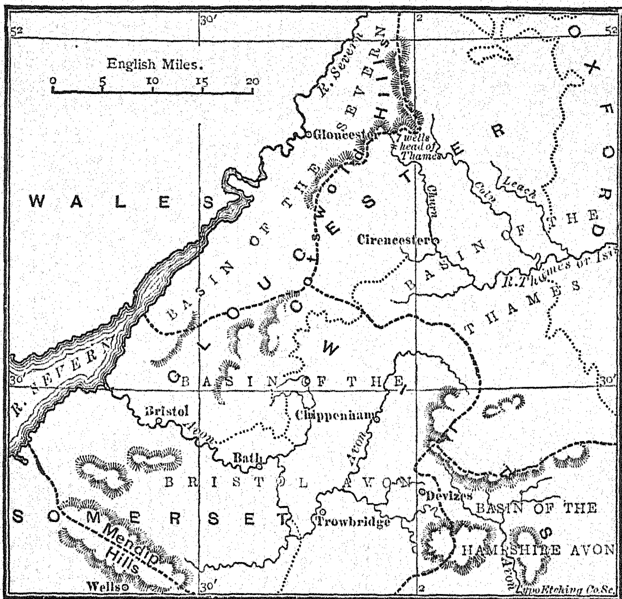


Fig. 77.—Watersheds of the Thames, Avon, and Hampshire Avon.

between the two sets of streams that run off the roof. It is easy to apply this illustration to a natural watershed. The ground from which streams flow always forms a watershed. As a rule it will be high ground, a hill or a mountain chain. Sometimes, however, a watershed may be formed of very low and flat ground, in which case the streams which flow from it will be short and sluggish.

Fig. 77 is a map of a part of the counties of Wilts and

Gloucester. It will be seen that the country included in the map contains the watershed of three well-known rivers —the **Thames**, the **Bristol Avon**, and the **Hampshire Avon.** The Thames runs into the German Ocean, the Bristol Avon into the Bristol Channel, and the Hampshire Avon into the English Channel. The line of the watershed is marked on the map; each river is surrounded on the map by a line, thus - - - - - -, enclosing three separate districts of various sizes. The country enclosed within these lines is that which is drained by the river which runs through it. Every stream, large or small, within the eastern district, runs into the Thames; every stream within the western district runs into the Bristol Avon, and every stream within the southern district into the Hampshire Avon. These districts are known as the drainage basins of their respective rivers. It will be seen that they differ very much in size. The basin of the Thames is much the largest of the three. The source of the Thames is far from the sea; the spring from which the river takes its rise in the Cotswold Hills is 215 miles from the point where the river runs into the sea below Gravesend. The whole basin contains no less than 6,000 square miles.

Principal English Drainage Basins.

The principal English drainage basins are as follows:—

Draining into the North Sea—the Thames, the Great Ouse, the Humber (including the Trent, Yorkshire Ouse, Wharfe, &c.), Tees, Wear, Tyne.

Draining into the Atlantic or St. George's Channel—the Severn, the Wye, the Avon, the Mersey.

Watersheds.

It would be natural to suppose that great mountain chains would always form the principal watersheds of the

countries in which they are situated; but this is by no means an invariable rule. It is a rule, on the contrary, which is subject to several very remarkable exceptions. In the centre of Europe, dividing the Austrian province of Poland from the kingdom of Hungary, rises the great chain of the Carpathian Mountains running from east to west.

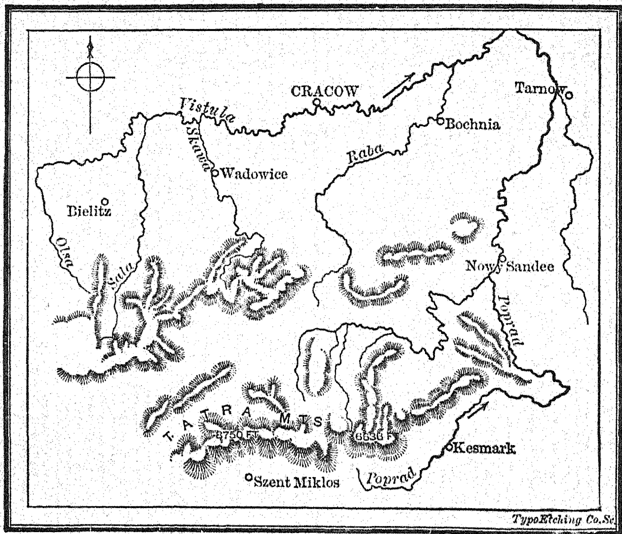


Fig. 78.—Watershed between the Baltic and the Black Sea.

At one part of this chain, known as the **Tatra,** the mountains attain a height of 8,750 feet. It would seem as if such a barrier as this must certainly form one of the principal watersheds of Europe. But, as a matter of fact, it does not do so. Strange as it may appear, the water which runs off the southern slopes of the Tatra finds its way into the **Vistula,** not into the **Danube,** and reaches the **Baltic** and not the **Black Sea** (Fig. 78). If we look at the map we shall see that the real watershed between north and south is not

the great ridge of the Tatra, but a little hill a thousand feet high which lies a few miles to the south of it.

The Brahmaputra and the Indus.

A still more remarkable illustration is afforded by the rivers which drain the plains of northern India, and by the **Brahmaputra** which flows through Assam into the Bay of Bengal. When we look at the map of India and see how

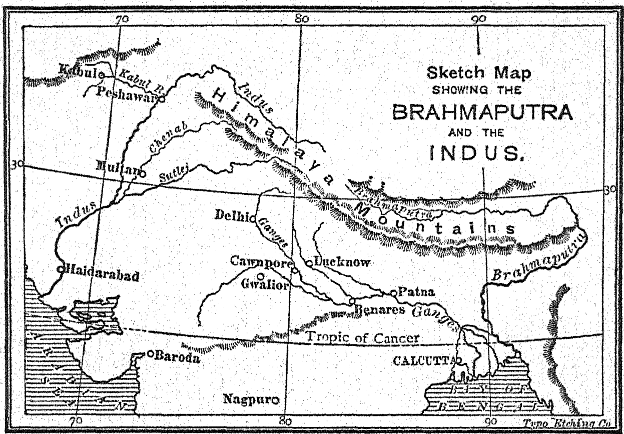


Fig 79.—The Ganges, the Indus, and the Brahmaputra.

the lofty chain of the **Himalayas** circles round the northern half of the peninsula, it would seem as if this huge range of mountains, rising in some places to a height of 29,000 feet, and stretching for hundreds of miles in an apparently unbroken wall from the Persian Gulf to the Bay of Bengal, must certainly divide the waters of Asia and form the watershed between north and south. Here again, however, we find on examination that our first impression would be wrong. Fig. 79 shows us a portion of the eastern Himalayas and the head of the Bay of Bengal. The first thing we

note is the course of the two great rivers—the **Indus** flowing westward, the **Brahmaputra** flowing eastward. Trace these two streams to their sources, and what do we find? We find that both of them rise on the north side of the great chain of the Himalayas, and that both of them force their way through the mountains into the plain on the south side.

The **Indus,** rising in the high land of **Tibet,** runs in a north-westerly direction at the back of the Himalayas for 600 miles, then turning south, it tears its way in great gorges right through the mountain wall and enters the plain. At **Attock,** where our English engineers have spanned its waters with a splendid railway bridge, it is joined by the **Cabul River** which, like the Indus itself, has cut its way through the mountains in the famous **Khyber Pass.** Nor does a single drop of the water which falls upon the north-eastern slopes of the Himalayas find its way into the **Arctic Ocean.**

For a long time geographers were at a loss to know whence came the vast amount of water that the Brahmaputra pours into the Bay of Bengal in time of flood. It is now certain, however, that this great stream has its sources 1,400 miles from the sea on the north side of the Himalayas, and that, like the Indus, it flows right through the range from north to south. Rising, like the Indus, in the high lands of **Tibet** at a height of 18,000 feet above the sea and at a distance of 1,800 miles from it, the Brahmaputra, known in its upper course as the **Singpu,** runs for 750 miles along the north side of the mountains, and then breaking through the mountain chain turns to the south-west into the province of **Assam;** then turning to the south it joins its waters to those of the Ganges and flows into the head of the **Bay of Bengal.** Thus it will be seen that it is never safe to judge hastily as to the direction which a river is likely to take; it is necessary to follow its course from its source to the sea, in order to be sure of the way in which it should be laid down on the map. It is not always by the shortest distance that

a river reaches the sea. It is not always the highest mountains which form the true watershed; nor do great mountain ranges always suffice to bar the course of a river.

The Work done by Rivers.

One of the most important things that have to be learnt in studying the geography of a country is the number, character, and distribution of the rivers which run through it. We shall find that in many ways rivers make a great deal of difference to a country and to those who live in it. The first thing we have to ask is, what is the number and size of the rivers, and in what direction do they run? Almost all rivers run towards the sea. A few, such as the **Chu** and some other rivers in Asia, spread out into numerous small channels, and lose themselves in the desert without ever reaching the ocean at all. But, as a general rule, a river runs down from high ground into the sea. It begins as a small spring or stream. As it flows, other springs and streams flow into it, and increase its volume, until it flows into a broad mouth or estuary, and empties itself into the sea. Whether a river be large or small, whether its course be slow or rapid, it is always performing a certain amount of work. As it flows, it carries with it earth, sand, and stones from the higher to the lower ground; with a ceaseless industry it does its part in levelling down the surface of the earth.

The amount of solid matter which is brought down by large rivers is astonishing. It has been calculated that the river **Ganges** alone brings down no less than 368,007,440 cubic feet of solid matter every year. It is hard to understand such enormous figures as these, but it may be easier to grasp the fact when it is explained that the amount brought down would cover a space fifteen miles square with mud a foot thick in a single year. It has been calculated that the **Mississippi** brings down an even larger amount

than the Ganges, the figures being 19,500,000,000,000 cubic feet. And what these great rivers are doing on this enormous scale, is being done on a smaller scale by every river and brook throughout the world.

Floods.

It is in times of flood that rivers do the greatest amount of work, and bring down the largest amount of earth and stones. The season of flood will depend upon the part of the world in which the river is situated. Our own English rivers are liable to be flooded whenever there is heavy rain, and there is no time of year when we are certain to be without rain. But, generally speaking, it is in spring that floods usually take place, and that the rivers bring down the greatest quantity of water. In the tropics, where several months of dry weather are followed by a "rainy season" of many weeks, the rivers rise with the fall of the rain at a regular time each year.

But the chief cause of sudden floods in rivers is the melting of the snows in the high mountains in which they have their sources. Many of the great rivers of the world rise in snow ranges—the **Rhine**, the **Rhone**, and the **Danube** in **Switzerland**; the **Nile** in the lakes fed by the snow falling on the mountains of **Central Africa**; the **Indus** and the **Ganges**, in the **Himalayas**; the **Yellow River** in the **Yung Ling**, in the mountains of **Tibet**. It is in the early summer, when the sun begins to melt the winter snows, that these rivers bring down the greatest volume of water, and with the water enormous quantities of earth, sand, and stones, all of which are carried down from a higher to a lower level.

Dangerous Rivers.

Sometimes this perpetual removal is the cause of very serious disasters. Wherever the river runs through a thickly populated country, attempts will be made to control and

regulate the annual floods. Sometimes this is done by deepening the channel of the river and thus allowing the flood water to run off without overflowing the banks. Sometimes in addition to deepening the channel, those who wish to control the river build embankments on either side. This is usually done where the country through which the river flows is flat, and the flood is likely to extend over a great surface if once it rises over the tops of the river banks. For many hundred miles the **Mississippi,** the greatest of the rivers of the United States, is thus bordered by embankments, or as they are there called, *Levees.* The river Po in its course across the plains of Italy is also banked up in many places. The **Hoang-Ho,** or **Yellow River,** in China, is also embanked for many hundred miles.

This process of embanking, however, is not without its dangers. As the flood comes down it brings with it, as we have seen, a large amount of solid matter. As the current slackens or as the waters fall, this solid matter falls to the bottom and forms a new bed for the river. The new bed is higher than the old one, and, in consequence, when a flood comes down the water flows nearer to the top of the embankment than it did before. Year after year the same process goes on until at last the embankment will once more have to be raised in order to keep the river in its channel. But though the danger may be overcome for the time, it is sure to occur again. Each year brings its flood, and each flood raises the river bed, until at last it often happens that the bed of the river is actually raised to a level with the plain through which it flows, and its waters are only confined by the artificial banks which have been built on either side of it. When such is the case, the danger is very great. The water will soon find out a weak place in the embankment, and will make a small breach through it. When once the breach has been made it is

quickly enlarged, and ere long the stream flows with irresistible force through the ever-widening gap over the flat plains which border the river.

Terrible calamities have over and over again taken place in this way. The breaking of the levees on the Mississippi has frequently led to the inundation of thousands of square miles of land and to fearful suffering and loss of life.

A River a Bad Master.

One of the most terrible disasters of this kind took place in 1887 in China in the province of Honan. A long continued season of rain swelled the waters of the Yellow River, which for many hundreds of miles is banked up by artificial dykes. The pressure of the water burst the dykes, making a breach nearly a mile wide. Through this breach the flood water poured down on the plain, and in a short time had covered no less than 10,000 square miles of country, an area equal to that of Yorkshire, Lancashire, and Lincolnshire put together, and sweeping away in its furious course 3,000 villages, with a population of over 3,000,000. The flood for a long time poured down in a wide and irresistible stream ten feet deep, flowing at the rate of twenty miles an hour. At length the river found a new channel for itself in which it settled down and through which it continued to flow. This was the ninth time that the Yellow River had thus broken through its banks, and once more the Chinese have begun to build up the dykes along the new course of the river, which will in all probability be broken down in their turn and become the scene of a tenth disaster.

A River a Good Servant.

It will, therefore, be seen that the greatest possible care must be taken in dealing with a great river. Water, like fire, is a good servant, but a bad master. We have seen

that a river may be a bad master; luckily there are plenty of ways also in which it may be made an excellent servant. Wherever we have a rapid stream, we have a great source of power which may be utilised for the service of man. From the earliest times the power of falling water has been used to turn watermills. In England there are still many places where water power is used, but our English streams are short, and in that part of their course in which they fall rapidly, bring down very little water.

It is on the Continent and in America that watermills are used on the greatest scale. The **Rhine** and the **Rhone** turn many wheels. In the city of **Geneva** hundreds of machines, great and small, are supplied with power by water-wheels in the River Rhone. In America the Falls of **Niagara** are used to keep in motion the machinery of many mills. There is scarcely any limit to the power of the water which comes down the Niagara River, and which springs in a leap of 160 feet over the cataract of Niagara. The water that is wanted to turn the mills is drawn off from the main stream in a canal, but the amount which is thus drawn off makes no appreciable difference to the enormous body of water which is carried over the fall, and which is at present allowed to run to waste. It has been calculated that the force of the water running over Niagara Falls is sufficient to run all the mills in the United States.

Irrigation.

In another way, also, the river may be made an excellent servant. It seldom happens in England that we are long without rain, and there are few portions of the country which ever suffer from a serious drought, but in many parts of the world there is a long dry season without any rain at all, and large tracts of land become useless for the purpose of cultivation owing to the want of water. To supply this want, recourse is had, wherever possible, to the process of

irrigation or watering the soil by bringing to it a part of the stream of a river. The practice of irrigation is a very ancient one. For thousands of years **Egypt** and **India** have both depended for much of the crops which grow there upon the extent of their irrigated land. Throughout the greater part of India are to be found large tanks or reservoirs built by ancient Indian princes, in which the swollen waters of the river in flood time, or the rains in the rainy season, were stored up, and from which they were allowed to flow over the land in periods of drought in specially constructed channels. Many of these great irrigation works were allowed to fall out of repair during times of war and disturbance, but since English rule has been established in India, a vast amount of work has been done in repairing old irrigation works and making fresh ones.

Millions of pounds have been spent in creating a great system of irrigation canals, and already very large profit has in some cases been made by the Government owing to the great importance of the land thus irrigated. Two things of course are necessary before irrigation can be successfully undertaken. In the first place, there must be a tract of country in which there is a large supply of water from which to supply the irrigation canals. In the second place this tract of country must be situated at a sufficient elevation to allow of the water being drawn off on to the lower country which is to be irrigated. Fortunately, in many parts of India, both these conditions exist, and every year these natural advantages are being utilised by British engineers. Valleys are being dammed up to form reservoirs, old channels are being cleared out, and new ones cut, and rich crops are now being obtained over many thousands of square miles which before were desert. In the province of Madras the Government valuation or tax upon unirrigated land is only 2s. 3d. per acre, while on irrigated land in the same district it is 9s. 6d., or thrice as much.

Irrigation in Australia.

In Australia irrigation is very greatly needed, for many of the rivers become almost dry in summer, and long droughts frequently occur. Large sums of money, therefore, are now being spent in forming irrigation works, by which the waters of the **Murray**, the largest of the rivers of Australia, may be used to fertilise the fields and pastures during those periods of drought which are unluckily of frequent occurrence in Australia. But a serious difficulty has arisen. The River Murray rises in the Australian Alps 1,000 miles from the sea. For a long distance it forms the border between **New South Wales** and **Victoria**, and it finally finds its way into the sea in **South Australia**. So great is the amount of water which it is proposed to take from the Murray in the upper part of its course, that the people of South Australia are seriously alarmed lest the whole of the water should be diverted from the river before it reaches them, and they should see nothing of the Murray but a dry and muddy bed.

The Nile.

That the whole of a great river can thus be "**drunk** up" by the fields which it is made to irrigate is proved by a remarkable example. In 1881 England was compelled to occupy Egypt. One of the first things that English officials had to do in the country was to improve the irrigation works which already existed. We know that from the time of Moses the whole prosperity of Egypt has depended upon the annual flood of the **Nile**. That great river, rising in the Albert Nyanza Lake, 3,850 feet above the sea, and 2,000 miles south of Cairo, is swollen every spring with the melting of the snows upon the mountains. The stream rises from 18 to 27 feet above its ordinary level, and it spreads over the flat plains on either side. When the melting of the snows is over, the waters recede and leave upon the surface of the land a coating of rich

mud, which renders the soil of Egypt one of the most fertile in the world. The whole fortunes of the people depend upon this annual flood. Cultivation is only possible where the rich mud has been deposited, and if the flood fall short of its usual limit, a loss of all the year's crop awaits those whose lands have not been reached by the waters. A *bad Nile* is a calamity to all Egypt, while a *good Nile* brings prosperity and satisfaction to all cultivators. As an ancient writer says, "The less the Egyptians see of their land the better are they pleased."*

It has always been the aim of those who sought the welfare of Egypt to extend as far as possible the area over which the Nile waters extended. From the time of the Pharaohs downwards, efforts have been made by Egyptian rulers to store up the water, and to extend the flood over the widest possible surface. Traces of great works of this kind remain in many places, nor has the task been neglected of late years. In 1843 French engineers commenced a great dam, called the **Barrage**, across the Nile at Cairo, the object of which was to dam up the flood waters. The work was not completed, and it was not until our own occupation of the country that it was again taken in hand. It has now been finished, and already the results have been most extraordinary. So completely has the work of irrigation been done, that the whole of the summer flow of the river has been actually drunk up by the land before it reaches the sea. There are times when actually no water at all runs into the sea below Cairo, the level of the river at that point being only the same as that of the Mediterranean Sea.

Here, then, we have some interesting examples of the work which is done by rivers; work which, well directed, may be utilised for the service of man, but which, when uncontrolled, may be a source of terrible calamities.

* Majorque est laetitia gentibus, quo minus terrarum suarum vident."
—Seneca, Quest. Nat. iv. 2.

Formation of Deltas.

We now come to another great piece of work which is accomplished by rivers, and of which, though the most remarkable examples are to be found abroad, specimens well worth our study can be seen at home.

There are a very few rivers which run a natural and uninterrupted course that do not form at their mouth what is called a **Delta**, that is to say, a tract of low and level land of triangular shape. This delta is sometimes actually below the surface of the water; at others on a level with it, and occasionally flooded when the river is high; or in other cases it is raised well above the bed of the river, and is covered with vegetation, and is fit for habitation.

Meaning of "Delta."

But before we go any farther, it is well to know what is meant by the delta of a river. The word itself is the name of the Greek letter D, which is written thus Δ, and it is easy to see why it was chosen to describe the formation of which we are speaking. Its triangular shape is exactly that of the alluvial tracts at the mouths of rivers. As a general rule a delta is intersected by a number of small streams—that is to say, the river near its mouth spreads out into the shape of a fan, and finds its way into the sea through a number of channels.

How a Delta is Formed.

It is not hard to see how the delta itself is formed. As the river, laden with solid matter, flows into the ocean, the force of its current becomes expended, and its waters no longer have the power to carry along the particles which are suspended in them. It is easy to see that, as the current slackens, the heaviest particles will be the first to fall to the bottom—that is to say, that they will be deposited nearest to the shore; the lighter particles will be carried farther down;

and farthest of all in the direction of the sea we shall find a deposit of mud made up of the very smallest particles carried down by the stream. Of course, as the bar which the river makes at its mouth becomes higher and higher, the obstacle to the water pursuing its ordinary course becomes greater and greater, and the stream, which hitherto ran into the sea, will turn on either side and run round the obstacle which it has created. Only a slight current will then run over that portion of the delta which was first formed, and the full stream will flow to the right and to the left.

When the weather is dry and the river low, this central portion will soon begin to show above the surface, and for a long time it will remain just on a level with the top of the water, sometimes submerged and sometimes visible. Then it may be that logs and drift-wood coming down the river lodge on its upper end and protect it from the water, or seeds may become bedded in the surface, and a growth first of weeds and grass and then of bushes and trees may appear on the top of it. In short, it will in time become an island with a river flowing on either side of it.

Meanwhile, the river is still going on depositing the solid matter which it brings down, and the process which we have seen and followed in one case will be repeated in another. Each new channel in turn will become "silted up" or obstructed, and again and again the river will be forced to find a new pathway to the sea.

The Delta of the Nile.

Fig. 80 shows one of the most famous deltas, that of the river **Nile.** The fertile land which forms it is intersected in every part by the narrow streams flowing from the river. There are many other great and important deltas in the world: there is one at the mouth of the **Ganges,** another at the mouth of the **Danube**; and here it is important to note that the fact of the river having more than

one mouth has had a very remarkable result; for the two mouths are in the possession of two different nations—the northern or **St. George's** mouth belongs to Russia, while the southern or **Kilia** mouth is Roumanian. In fact, as has been said, there are very few rivers which have not formed a delta of more or less importance. It is necessary to remember that every river has not succeeded in raising its

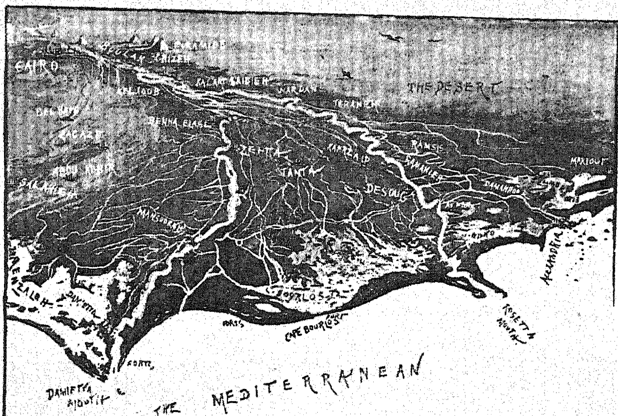


Fig. 80.—A Delta above Water—the Delta of the Nile.

delta above the surface of the water, and that many influences, such as the strength of the current or the power of the tide, may prevent the delta ever becoming dry land.

The Delta of the Thames.

For instance, at the mouth of the river **Thames** there is a great delta formed in much the same way as the delta of the Nile, and like it divided by a number of channels of different sizes. If we were to go down from London to the **Nore** in a steamer we should, however, see nothing of this delta. At the same time, if we were to undertake a voyage without

the guidance of a Thames pilot or somebody who had a practical acquaintance with the geography of the river, we should very soon have the best reasons for knowing that a delta in fact existed, for there is very little doubt that long before we reached the open sea we should be aground

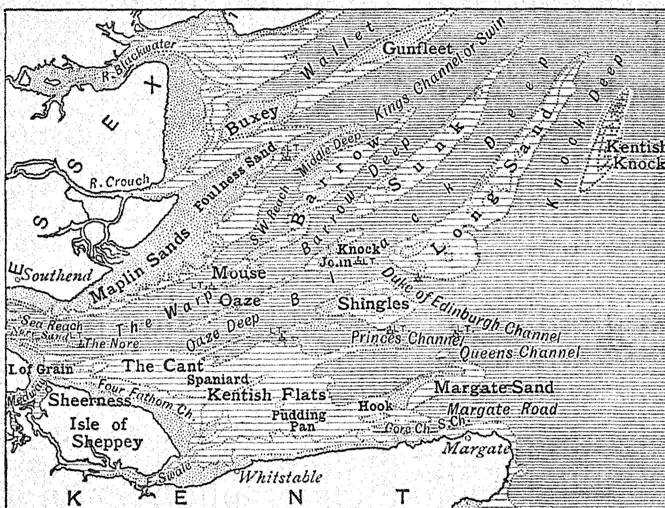


Fig. 81.—A Delta under Water—the Mouth of the Thames.

upon one of the many sandbanks which bar the entrance to the port of London.

Fig. 81 is copied from the chart of the mouth of the Thames, and we shall see that there exists under water a formation which is for all the world like that which exists above water at the mouth of the Nile, and that the Rosetta mouth and the Damietta mouth are replaced by the channels which are familiar to all who sail from London —the **Swin**, the **Princes**, the **Duke of Edinburgh**, and so on.

Some Familiar Examples.

Nor is it at the mouth of the Thames only that we can find an example of a delta in England. Wherever a river runs into a lake, or a stream runs into a pool, or a gutter runs into a puddle, we can find an example, and the best and the easiest way after all of studying the formation of which we have been speaking is to examine the deposit which has been left by almost any little stream which finds its way into a puddle upon a rainy day; and here it may be said that the amount of geography and geology, too, which may be learnt on any muddy or sandy road after a good drenching shower is very considerable. The higher ranges, with the streams pouring from their sides and cutting their way through deep valleys; the upland lakes which gradually drain themselves dry and become alluvial basins; the lower valleys still half full of water and half of rich alluvial mud; the deltas formed according to rule, the upper part small gravel passing into sand, and finally into mud—all these and many other object lessons may be studied within a stone's throw of our own doors, and a very interesting and pretty study it sometimes is for anybody who has patience enough to undertake it, and who knows enough to understand it.

Summary.

1. The deposit of alluvium at the mouth of a river leads to the formation of a delta.

2. A delta is sometimes above water, as in the case of the delta of the Nile; sometimes under water, as in the case of the delta of the Thames.

Explanation of Terms.

Delta.—A triangular piece of land at the mouth of a river formed by the deposit of alluvium brought down by the river.

CHAPTER XVI.

ALLUVIAL VALLEYS.

Another View of a River.

WE spoke in the last chapter of rivers, and of the way in which they find their way into the sea, the work which they do in their progress, and the dangers and benefits which are connected with them. We are now about to consider a river from a different point of view, and examine how far it influences the lives of the men who live on its banks. We shall see that great rivers have a very marked and important influence upon the distribution of population throughout the world, and upon the habits and occupations of men.

The Situation of Great Cities.

There is a great difference between different parts of the world, and, indeed, between different parts of England in the matter of *population*. In some parts the population is very dense—that is to say, a great many people live close together. In others it is very scattered, and some districts, as for instance, the top of Dartmoor, the higher parts of the Westmorland mountains, are without any inhabitants at all. When we come to ask why it is that one part of the country is more closely populated than another, and why towns are found in one portion and not in another, geography will help us to give a very important part of the answer.

Let us look at the chief towns of the great countries of the world, beginning with our own. First we have **London** situated upon the *Thames;* then we have **Paris** upon the *Seine*, **New York** upon the *Hudson*, **Calcutta** on the

Hooghley, **Rome** on the *Tiber*, **Vienna** on the *Danube;* all these are great and important cities, and in connection

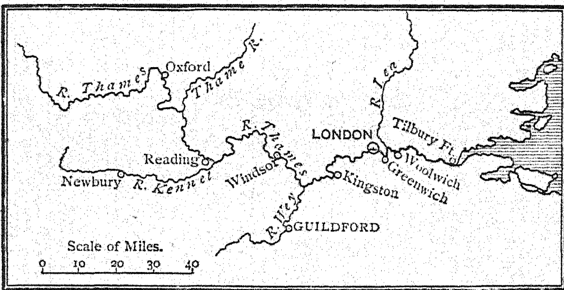


Fig. 82.—The Valley of the Thames.

with each name we have mentioned one geographical fact. What is that fact?

It is that each one of these places is situated upon the banks of an important river.

Let us see whether this fact, which is common to all,

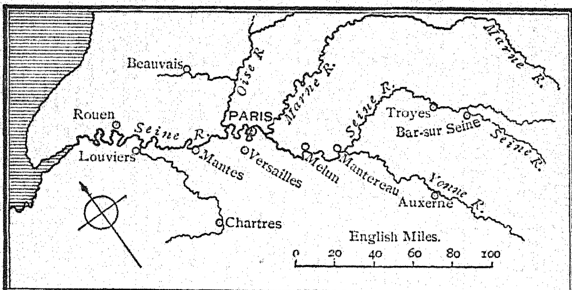


Fig. 83.—The Valley of the Seine.

has not something to do with the existence and the size of the town in each case. As a matter of fact it has a great deal to do with it. There is no rule without an exception, and we shall speak of the exceptions to our rule a little

farther on. Nevertheless, it may be laid down as a general rule that *all the great cities of the world are situated on the banks or at the mouths of rivers.* Nor is this all that may be said on this head. If we follow up the

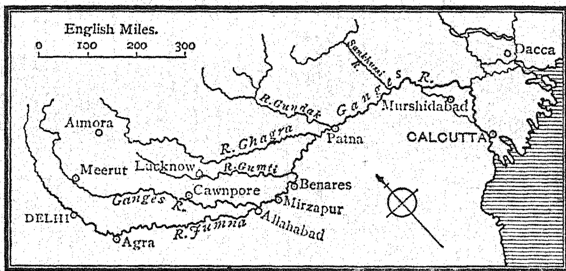


Fig. 84.—The Valley of the Ganges.

valleys up to the source and down to the mouth of the rivers, we shall find that there are many other important towns situated within them—in other words, that along these valleys

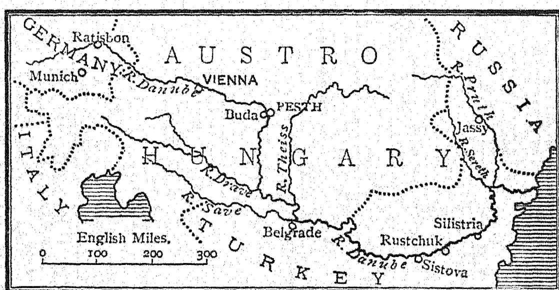


Fig. 85.—The Valley of the Danube.

the population is generally very dense. Thus, in the valley of the *Thames* we have **Sheerness, London, Reading, Oxford**; in the valley of the *Seine* are **Elbœuf, Rouen, Havre**; in the valley of the *Danube* are **Ulm, Ratisbon, Lintz, Vienna, Presburg, Buda Pesth, Belgrade**; and

in the valley of the *Hooghley*—or rather of the *Ganges*, of which the *Hooghley* forms the lower part—are the great towns of **Cawnpore, Allahabad, Benares, Patna,** and **Calcutta.**

Alluvial Valleys.

Now we have arrived at what seems like a geographical law with regard to the position of towns and their connection with the course of great rivers, and if we look a little closer and inquire what is the nature of the valleys in which these towns are situated, we shall find that they are in all cases what are called **alluvial valleys**—that is to say, the bed of the valley is composed of the *alluvium* of the rivers which run through them. It is easy to explain what is meant by "alluvium." As the river rolls downwards to the sea it brings with it from the mountains from which it rises and from all parts of the country through which it flows a large amount of soil worn away by the action of the water from the banks of the river and from the banks of the streams which run into it. As the river descends into the plain, and as its course becomes slower, the heavier portions of the soil which it bears sink to the bottom and are distributed over the bed of the river. The lighter portions are carried farther down the valley, and they too at last sink to the bottom and form the river mud.

A Warwickshire Stream.

But as a matter of fact no river which has not been banked up by artificial means always runs in the same bed. Anybody who has used his eyes in any of our midland counties will know how true this is. Let us take the River *Avon*, which winds in innumerable curves through the middle of Warwickshire. It is a small river, but it gives us a very good illustration of what happens in the case of very much larger rivers. At each turn of the river a small cliff, some-

times not more than a few feet high, will be found on the outside of the curve, and a little bank of mud on the inside. This is caused by the pressure of the water sweeping round the outside of the curve, and making an eddy or backwater in which the soil brought down by the river is deposited.

Gradually the stream wears its way into the outside shore, and at last the current, instead of flowing in the direction

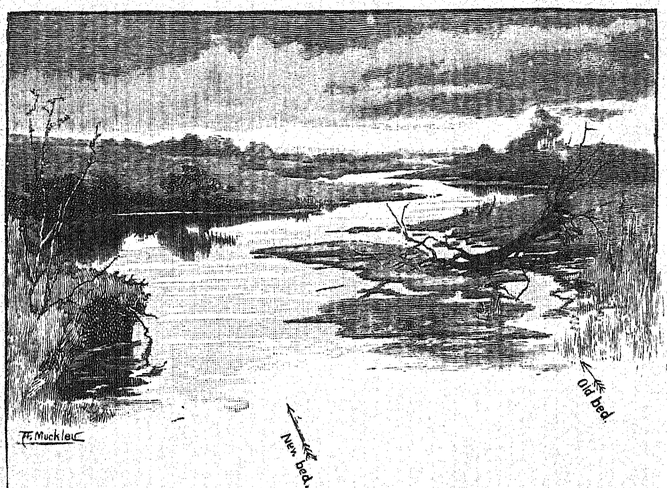


Fig. 86.—A Midland Stream.

marked by the arrow on the right, will flow in the direction marked by the arrow on the left. Then we shall see at once that this alteration in what is called the *set* of the current will at once begin to change the form of the bank, and will in time alter the course of the river. So, too, a very small obstruction in the bed of a river—a fallen tree or a slip of earth—may for a time change the direction of the current, and a part of the bank which was before protected will now become exposed to the action of the water and once more the direction of the river will be changed (Fig. 86).

Again, in flood time, when the river rises above its banks, all the ordinary currents of the river will change their direction, and sometimes the river will cut a new way for itself through the adjoining land. In any case, when the waters have fallen to the usual height, a deposit of mud will be left upon either bank where the water has been. And it must not be forgotten that a similar deposit of mud is always being formed upon the bed of the river itself. Thus it stands to reason that in time the bed of the river will be raised, and at last the old channel being insufficient to hold the water, the stream will either overflow its banks, and become shallow and broad instead of narrow and deep, or it will choose some other path to get to the sea.

In all these ways the direction of a river bed down a valley will change from time to time, and will cross the whole valley from side to side, and each succeeding year the river will add a thin coating of soil or alluvium to some portion of the valley.

Now this soil, which has been broken up very finely by the action of the water, and which often contains large quantities of vegetable matter, such as trunks of trees. decayed leaves, etc., is usually what is called a very rich soil, which is easy to cultivate and produces better crops than the higher land from which it has been brought down.

Facts and Conclusions.

Now we have two facts to go upon :—

(1) *That the valleys in which great rivers run are usually occupied by large populations.*

(2) *That such valleys are for the most part what are calle1 alluvial valleys, poss ssing a rich soil.*

It is not hard to put the two facts together and to understand that the one gives a reason for the other. The great towns naturally grow up in the fertile valleys, and the

position and number of the population are accounted for by a geographical fact.

Tidal Towns and Rivers.

It is easy to see also that a very convenient position for a great town is a short distance from the mouth of a river, where the effect of the tides is still felt, and where the river is deep enough to allow ships to bring their cargoes up to the city; and at the same time where it is sheltered enough to allow of the ships being protected from the action of the waves.

It is hardly necessary to go through a list of great towns so situated upon the tidal water near the mouth of great rivers.

London, situated on the great tidal estuary of the Thames, is an example among many others of this truth. The important ports of **Hamburg** on the *Elbe*, **Antwerp** on the *Scheldt*, **Havre** on the *Seine*, **New Orleans** on the *Mississippi*, and many others likewise illustrate it. It is worth while noticing, however, that though a great many old towns are situated upon tidal rivers, they are often so far from the sea that they have little value as ports for the large ships which cross the ocean.

It is not difficult to understand how this has come about. In former times the ships which carried on the commerce of the nations were very much smaller than they are at the present, and consequently could go much farther up the rivers than the great steamers of 5,000 to 10,000 tons which carry cargoes and passengers at the present day. As long as the ships could get up to a town at high water, it did not much matter how far inland the town was; or rather, it was an advantage that it should be some distance from the sea. In the first place, the waters of the river were smooth and protected from storms, and small ships could lie close to the bank and could discharge their cargoes on either side

of the river; and lastly, it must not be forgotten that in times when sudden raids and incursions from the sea were not unknown it was safer for the ships to take shelter as far from the coast as possible. Now, however, when the size of ships has been very greatly increased, these inland towns no longer enjoy their former advantages.

The largest ships which were built could formerly sail up the *Avon* to **Bristol**, the *Severn* to **Gloucester**, and the *Thames* to **London Bridge**. Now, however, none of the great ships which carry our commerce can reach the places we have named, and they are compelled to stop at **Avonmouth**, at **Cardiff**, or at the docks some miles below **London Bridge**.

The Value of a Situation on the Sea.

It is natural enough that those towns which once were great commercial ports, but which have seen their prosperity taken away by a change in the methods of shipbuilding, should be anxious to get back what they have lost, and as a matter of fact many of them are trying to do so.

Nor is this all. In former times the people of England were much less dependent for their prosperity upon the goods, merchandise, and food which was brought to them over the sea, than they are at the present day.

The commerce of the United Kingdom alone is worth £900,000,000 a year. We depend for the bread we eat upon the safe arrival of our ships. *Out of every twelve loaves of bread that are eaten in this country, seven are made of wheat which comes from over the sea.* So, too, another article, scarcely less important to us than corn—namely, the **cotton** which is used in Lancashire mills, and the manufacture of every pound of which gives employment to so many thousands of people, comes to us by sea.

Thus it comes about that it is now much more important

to the welfare of any town to be on or near to the sea than it used to be, and it is a great advantage for the merchants and manufacturers in a town to be able to obtain the goods they require direct from the ships in which they arrive, and thus it has come about that not only those towns which were formerly great seaports, but which, owing to the increase in the size of ships, have ceased to keep their position, but also many inland towns which have hitherto had no means of communication with the sea are trying their best to turn themselves into seaport towns. They cannot,

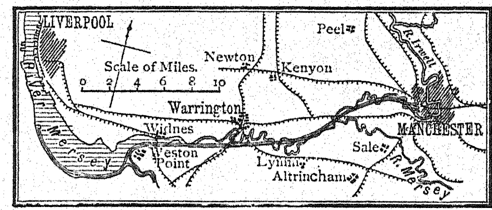


Fig. 87.—The Manchester Ship Canal.

it is true, go to the sea, but they are doing what they can to bring the sea to them. Hence it is that we hear of great **canals** being made in every country.

Canals.

The French have completed a great system of locks upon the Seine between Paris and the sea, by means of which vessels of 800 tons burden can reach the city; and it has been contemplated to greatly increase the size of these locks, so that the shipping which now stops at Havre may go up to Paris itself.

In England we have the example of the **Manchester Ship Canal,** an enormous undertaking on which more than ten million pounds have been spent in order to make thirty-six miles of canal, the object of which is to bring the ships from America and other parts of the world up to **Warrington, Manchester,** and **Salford** (Fig. 87).

In Holland a great ship canal has been made connecting **Amsterdam** with the sea (Fig. 88), and in England many projects are on foot for making inland towns into seaports. It is too late to bring the towns to the sea, and so we are doing our best to bring the sea to the towns.

These examples have been given to show once more the connection between the geography of a country and the

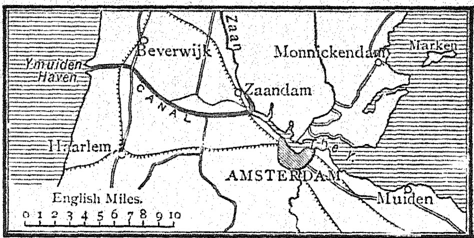


Fig. 88.—The Amsterdam North Sea Canal.

condition and distribution of the people who live upon its surface. It will be remembered, however, that in the earlier part of this chapter we said that as to all rules there are exceptions, so *to this rule, that great populations will be found to be situated in alluvial valleys, there are exceptions.*

Exceptions.

One of the principal exceptions referred to must have struck the reader when we enumerated the list of capital towns which fell in with our rule and yet left out the great capital of **Berlin**. Now Berlin, which is a city of over a million inhabitants, and which, moreover, is the capital of the German empire, is not situated either on the sea or in the valley of a river of any importance. On the contrary, it lies in the midst of a sandy plain on the banks of a little stream called the *Spree.* It is scarcely more than a sluggish canal, and it is of little value for any commercial purpose. But

after all, it will be found that though Berlin and one or two other towns like it are apparent exceptions to our rule, the reason for the exception is of a kind which gives force to the rule itself.

It may be taken as certain that if Berlin had depended for its rise upon its commercial prosperity only, or on what may be called natural development, it would never have

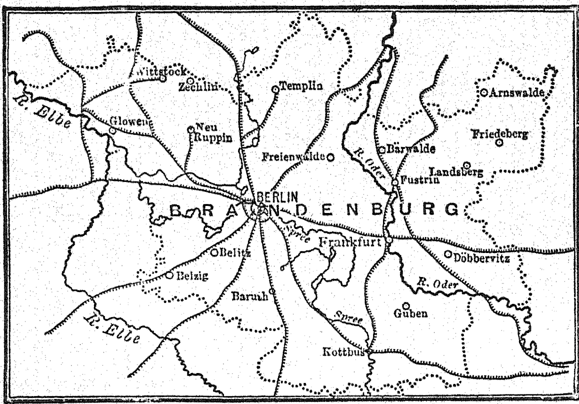


Fig. 89.—Map of the Province of Brandenburg.

attained to its present size and importance. But **Berlin** *has from the very first been maintained for political reasons* by those who were quite willing to sacrifice every consideration to political or to military necessities. Berlin was the centre of the electorate of **Brandenburg,** and the people of Brandenburg being a strong and energetic people beset with perils on every side from surrounding states, and favoured with very few natural advantages, were compelled at a very early date to organise themselves with the greatest possible care in order to preserve their position at all in Europe. They were compelled to form and to

maintain an army and a civil administration capable of being controlled and directed from one spot, an administration which should be always efficient and at the same time as central as possible and as far removed as possible from danger.

Hence it was that Berlin having once become the seat of government, grew with the political extension of Brandenburg. When **Brandenburg** grew into the kingdom of **Prussia,** Berlin still remained the political and military capital, which increased in size and importance, not because the trade of Germany centred there, or because the commerce of Europe arrived there, but because the electors and kings of Brandenburg and Prussia decided that Berlin should be and should remain the centre of the state which they had organised, and of the army which they had created (Fig. 89).

The Rise of Prussia.

In 1866, when Prussia defeated Austria at the battle of Sadowa and became mistress of all North Germany, including Hanover, Berlin still remained the most important town in Prussia, and it was Prussia which was still the real strength of the North German Confederation. **Hanover, Hamburg, Cologne, Leipsic, Breslau,** and other great towns were important centres of commerce, art, and literature; but though commerce, art, and literature are all very important to Prussia and to North Germany, the most important thing of all was that Prussia and North Germany should live and hold their own against enemies on the south, east, and west. The soldier and the statesman were still the most important figures in North Germany, because unless they were successful all else was in danger.

So once more when Prussia in 1870-71 at the head of the German States defeated France, and when William of Prussia was crowned Emperor of Germany at Versailles, Berlin became the **capital of the German Empire,** an empire

including the great cities of **Cologne, Hamburg, Leipsic, Breslau**, and many others, all flourishing and most important centres. But still in 1870 as in 1866, and in 1800, Berlin remained the real capital of Germany, because the Statesman and the Soldier still were necessary above all for the maintenance of the new empire, and because the chief statesmen and the chief soldiers still maintained their place in Berlin. And so it happens that Berlin, which has from beginning to end been the artificial capital, remains so to this day, and has increased to its present population and its present prosperity, *not because of, but in spite of its position.*

SUMMARY.

1. As a rule great towns are situated on the banks or at the mouths of great rivers.

2. The valleys in which great rivers run are usually formed of a rich "alluvial" soil.

3. It is important to large cities to have access to the sea.

4. Berlin is an example of a city not on the banks of a great river.

5. The reasons which determined the situation of Berlin were political.

EXPLANATION OF TERMS.

ALLUVIUM.—Soil washed down, and deposited by a river or stream.

ALLUVIAL VALLEYS.—Valleys formed of soil so deposited.

CHAPTER XVII.

HISTORICAL GEOGRAPHY.

History and Geography.

WE spoke in the Introductory Chapter of *Historical Geography*. Nothing is more certain than that to study history without a knowledge of geography is to miss a great part of what history can teach us. It is true, on the other hand, though not perhaps to the same extent, that the study of geography ought to go hand in hand with the study of history. There are certainly some geographical facts which are not half understood unless we approach them with some knowledge of human history.

We propose, therefore, in the present chapter to consider shortly how far history and geography are bound up together, and what is the meaning of the term **Historical Geography.**

Let any traveller wander through Europe, and note down as he goes the names of the towns he visits, the rivers he crosses, and the countries he passes through; and if he content himself with setting down the names only, without making any effort to learn what these names can teach him, he will have made a very unprofitable journey. How much has he not lost by his failure to supplement the knowledge which comes through the eye by that which history and tradition, written in books, or in the names and characters of the places themselves, can supply? Let us learn from a few examples what the traveller who passes over the surface of the earth without knowledge or a care for the history of the men who have lived upon it may miss.

Marathon.

The traveller who leaves Athens by steamer and passes north-eastwards up the narrow channel which separates the mainland of Greece from the long island of Eubœa, will see on his left hand a sweep of level plain fringing the sea, and

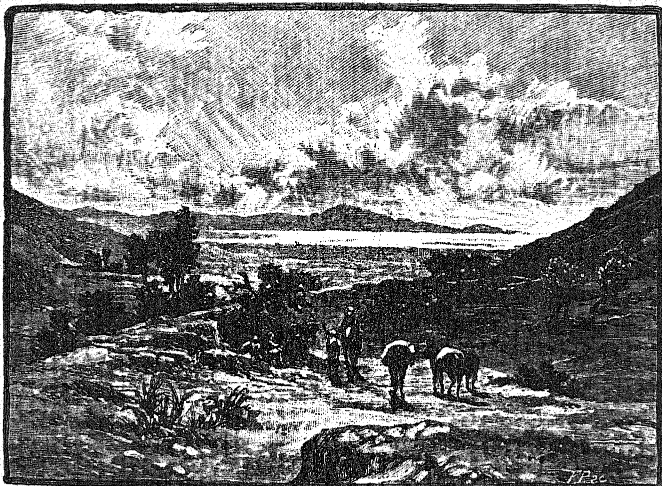


Fig. 90.—The Plain of Marathon.

backed by a low range of blue-grey mountains. If he consults his guide-book he will learn that these are the spurs of Mount Pentelicus, and that the plain at their foot is the plain of **Marathon.**

> "The mountains look on Marathon,
> And Marathon looks on the sea."

So they looked over two thousand years ago,* and so they do to this day, and the mountains and the plain are all that the traveller will see who knows nothing of the great story of

* The Battle of Marathon was fought B.C. 490.

ancient Greece. Surely he will have only half seen Marathon if he fail to call to mind that great day when this sweep of the Grecian shore ran red with the blood of Greek and Persian, shed in the great fight in which the genius and

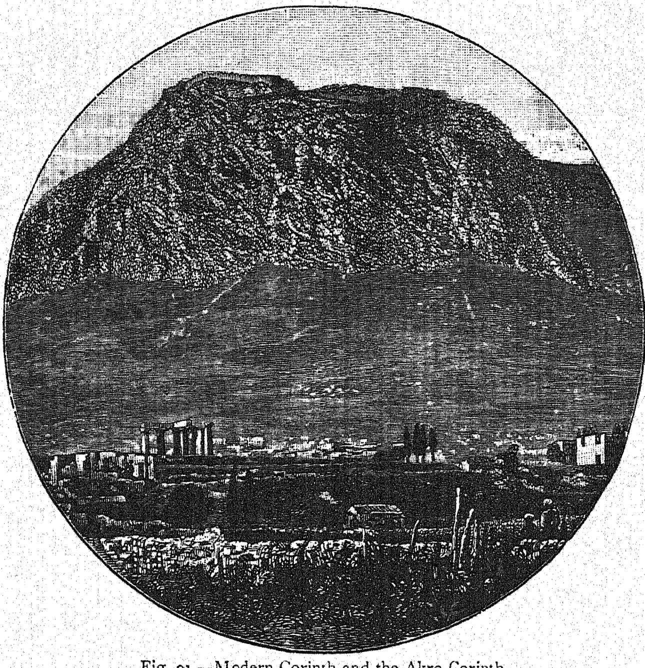


Fig. 91.—Modern Corinth and the Akro-Corinth.

valour of Greece, for once united in a common cause, broke the power of Persia, and drove Darius in headlong flight back to the East.

Corinth.

To the eye of the modern visitor the deserted and squalid heap of ruins which mark the site of **Corinth** *

* The ruins of Corinth, at the western end of the isthmus of that name, mark the site of the old city destroyed by a succession of earthquakes.

presents a spectacle of dreariness and desolation only; but to the eye of the historian it marks the last stage in the long story of the great city of **Corinth**—the wonder of the ancient world, the most corrupt of the churches, the prize

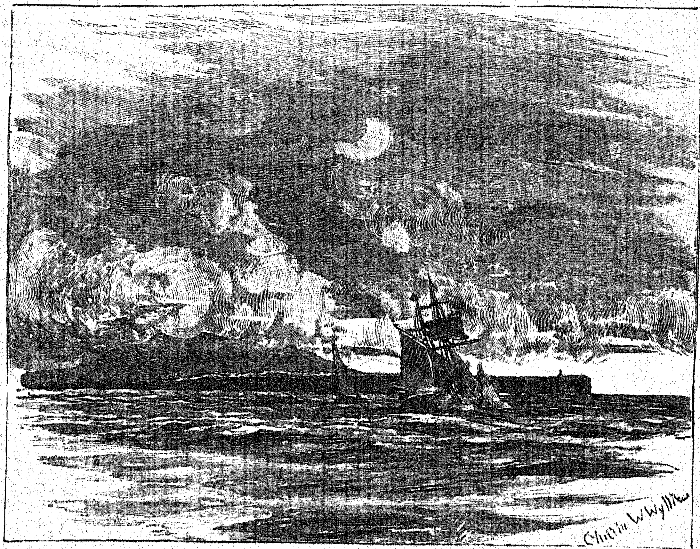


Fig. 92.—Cape St. Vincent.

fought for and lost or won by Greek, Barbarian, Turk, and Christian through a long series of years.

Trafalgar.

As the great ocean steamers hurry on their way from London or Southampton to the distant parts of India and Australia, bearing with them English hearts and English hands to do the work of our race across the sea; as the returning ships near the little island which every English-speaking man and woman on board loves to call "Home,"

the course lies for a short space within view of the coast of Spain. A rocky headland lies down on the horizon. We ask its name—it is **Cape Trafalgar.** To the Briton the mere name is a history. The headland is no longer only a

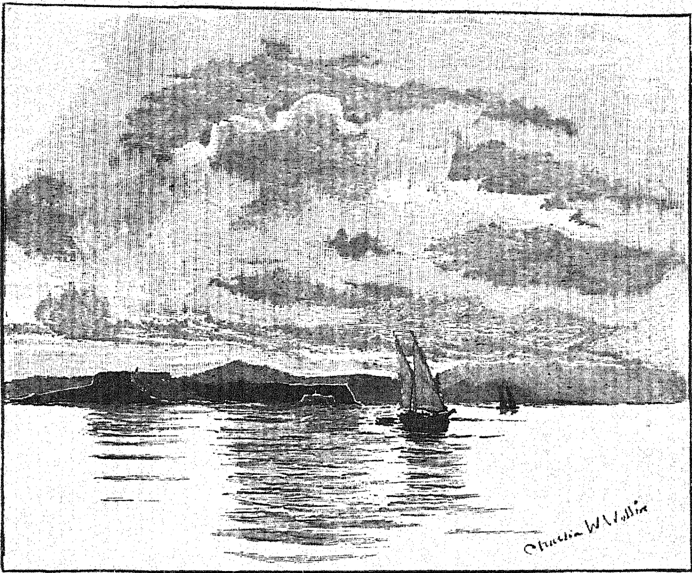


Fig. 93.—Cape Trafalgar.

landmark which helps to mark the weary progress of his voyage, but it is an historic spot, a memorial of the triumph and the sorrow of his people.

"Nobly, nobly, Cape St. Vincent to the north-west died away;
Sunset ran, one glorious blood-red, reeking into Cadiz Bay;
Bluish, mid the burning water, full in face Trafalgar lay;
In the dimmest north-east distance dawned Gibraltar, grand and gray;
Here and here did England help me; 'How can I help England?' say,
Whoso turns as I, this evening, turn to God to praise and pray;
While Jove's planet rises, yonder, silent over Africa."

If we can find in these lines a strain that stirs us, and a thought that helps us, we shall have learnt to understand how history, and the memories which history preserves, can be made to adorn and complete the study of geography.

And once more, if we come to our own land, we find many a similar example.

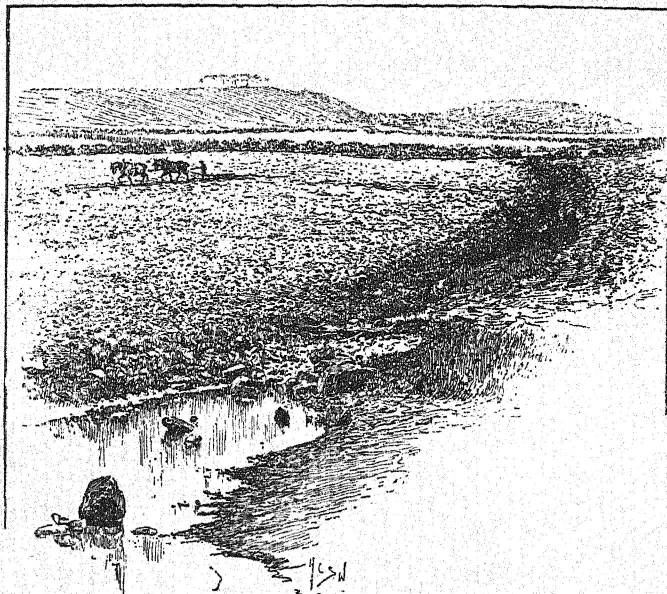


Fig. 94.—Flodden Field.

Flodden.

We can stand on the dusky ridge of **Cheviot** and look down on the sluggish river winding below, and see nothing more. But there is something more to see if we can use our mind and our memories as well as our eyes. We can surely recall that morn when—

> ——"to many a trumpet clang,
> Twisel! thy rocks' deep echo rang.

> The hawthorn glade, which now we see
> In spring time bloom so lavishly,
> Had then from many an axe its doom,
> To give the marching columns room."

We can see King James, "the champion of the dames," sit idle while the fortunes of his kingdom are hazarded and lost under his eyes, until

> "The precious hour had passed in vain,
> And England's host had gained the plain;
> Wheeling their march, and circling still
> Around the base of Flodden Hill."

And then, too late, he sees that Surrey has won the position of vantage. FitzEustace cries

> "Hark! hark! my lord, an English drum,
> And see ascending squadron come
> Between Tweed River and the hill.
> Foot, horse, and cannon, hap what hap,
> My basnet to a 'prentice cap
> Lord Surrey's o'er the Till."

The Real Connection between History and Geography.

But the connection between history and geography to which we wish to call attention is something different from and beyond this mere recalling of the memories which surround the famous places of history. The study of historical geography depends not upon sentiment or general recollection, but is concerned with a very careful examination of the connection between human history on the one hand, and the distribution of the human race over particular portions of the earth's surface on the other; and as part of this inquiry it deals with the record of their history which bygone peoples have left upon the surface of the earth in the names which they have given to places which they once inhabited.

Some of the earliest and most important incidents which

connect the study of geography and history are the great movements or migrations of the people of Asia towards the West, which began about the time of the Christian era.

Wave after wave of warlike nations moved slowly onwards from the centre of Asia towards the Atlantic Ocean. Some halted long on the way and then resumed their march. Others, generally the later comers, remained in the spot which they first occupied.

It is the work of the student of European history to trace these movements and to discover to which part of Europe each migration tended. By so doing, he learns to account for the various characters of the different races of modern Europe, for the languages which they speak, and for their personal appearance.

The Goths.

The records of history are full and clear with respect to the invasion of Italy by the **Goths.** We know that **Alaric** crossed the Alps in the year 410, captured the city of Rome, and ruled as Roman Emperor. His hardy followers received throughout Italy the lands which were the rewards of their services, and to this day we can trace throughout the whole of the plain of Lombardy, which forms the northern part of the Italian Peninsula, the result of the mixture of the northern people with the Latin race which occupied the country they conquered.

The Basques.

Sometimes history fails to tell us the true story of a modern people. On the northern coast of Spain, there is to be found a small population living in the midst of Spaniards, talking a language which not only is not Spanish, but which is unlike any other European language. These people are the **Basques**, and the most patient students of history have not yet been able to find out why this little

district should be so peculiar and should be different in respect to the people who live in it from any other district in Europe.

Sometimes we have to read backwards the lesson which we learn in the case of the invasion of Italy by the Goths. In that case we know that the Goths did, as a matter of fact, advance from Eastern Europe and pour down upon Italy. The name and exploits of Alaric are made familiar to us by practised writers whose works are still preserved. We know the fact, and we therefore look for its natural consequences. We find, as we should expect, the clearest possible proof of Alaric's invasion in the things which we see in Italy at the present day.

Finland and Hungary.

But there are other cases where we find facts which history does not explain, and we have then to see if we cannot discover from the nature of the facts how they must have come about. If we look at the map we shall see that the Russian duchy of **Finland** and the kingdom of **Hungary** are very far apart. 1,600 miles divide **Abo** from **Buda Pesth**, and at first sight it would seem that there is little in common between the people who live on the wintry shores of the Baltic and the nation which occupies the sunny plains and golden corn-fields which border the great stream of the Danube.

But a very little inquiry will show us that in one respect at any rate there is something in common between Finland and Hungary. The people of both speak a language which is unlike that which is spoken by any of their neighbours or by any of the western nations, and if we go farther and ask those who are familiar with **Finnish** and with **Magyar**, the language of the true Hungarian, whether there be any other peculiarity in which the two countries are alike, they will tell us that there is a resemblance between the two languages

which is sufficiently strong and sufficiently clear to make it certain that Finnish and Magyar are really branches of the same speech, and that at one time the Fins and the Magyars must have been one people. And this indeed appears to have been the case; and it seems true that the last great invasion of Europe from the east was by an Asiatic race which divided into two branches as it came westward, the one passing north till it reached the shores of the Baltic, and the other southward to the plains of Hungary.

Lessons Near Home.

These are examples of only one very interesting part of historical geography, and it is true in this case, as it has been in every other case which we have spoken about, that the study of our own country will furnish us with examples, no less readily than the continent of Europe, which will help us to understand what geography has to teach us. Indeed, the history of England has been, on a small scale, the same as the history of Europe. Invasions have always come from the east, and as a consequence, whenever those invasions were successful, the people who were already in the country were pressed back towards the west by the invaders. Thus we find that it is in **Wales** and in **Cornwall**, the western extremities of this country, that the descendants of the early **British** population are to be found. The **Saxon** invaders, landing on the east coast, gradually crushed the Britons back against the sea, and when in their turn the **Danes** attacked the Saxons, they landed in **Essex**, **Lincolnshire**, and **Yorkshire**, and drove the Saxons southward and westward. And hence it is that at this day we find the strongest traces of Danish settlement along our north-east coast, and down as far as the line of the **Trent**, which formed for many years the Danish border.

We spoke of Briton, Saxon, and Dane, and of the traces they have left, and those traces are clear enough to

anybody who chooses to look for them; but it is not everybody who has tried to learn the historical lessons which are set out under his own eyes in his own country.

Welshman.

It is not hard to understand that the **Welsh** are sprung from a race which is not the same as that from which the majority of Englishmen come. The fact that the Welsh language is still spoken makes this clear enough. To those who do not understand Welsh the names of mountain and stream, village and lake in Wales seem strange, but to those who know the language these names are as familiar and convey as clear a meaning as our common English place names. *Wood Side*, *Red Ditch*, *Black Water*, *Ox Ford*, are all simple names, which our English forefathers gave to things and places which they saw. And so in Wales the common country names mark just as certainly the old history of a people. **Llwmpia, Llwyn Helig,** and **Pontrhydvendiged.** Strange as the names look to us they are familiar enough to a Welshman, to whom they mean "Magpie's Grove," "Willow Grove," and "The Bridge of the Blessed Ford," respectively.*

Dane.

As for the traces of Danish invasion they are indeed clear and plentiful, but it is north countrymen who have the best opportunities of studying them.

To this day our own fellow-countrymen in Cumberland talk a language which is very nearly akin to pure Danish, and which came to them straight from Sweyne and Canute.

And all through the north we find names ending in "by"—**Appleby, Kirkby, Ingerby, Derby, Grimsby,** and

* *Pont*, a bridge, *rhyd*, flowing water, *vendiged*, blessed—the name of a bridge on the Sacred Pilgrim road to the abbey of Strata Florida, in Cardiganshire.

hosts of others which mark Danish settlements and Danish names; while along the rivers we find the flat meadows in Yorkshire and Durham spoken of as "**holms**"—**Brownsholm, Longholm, Broadholm,** recalling plainly enough the *Nordholm*, *Stockholm*, and *Breitholm* of Scandinavia. A careful student of our north country language has made a very interesting collection of the Danish words still used in East Yorkshire. At first sight "*pepper cake*" looks an odd name for a somewhat uninviting delicacy; we learn, however, that it is nothing but "*leber kage*," a cake of wheaten flour, spiced and seasoned with pepper and honey. A "*shock bock*" means a rover, from the Danish word "shock," to rove; "*slape*," which, every Yorkshireman knows, means slippery, is from "sleber." "*Crack*," talk; "*midden*," an ash-pit; "*flit*," to move house; "*stunt*," obstinate; "*beck*," a stream, are all pure Danish words, and many others might be added to the list.* And we find many other traces of Danish occupation, some of them plainly to be seen, some of them which we shall only recognise by keeping our eyes open and our wits about us.†

Saxon.

And those of us whose ancestors are neither British nor Danish, but who look back to stout **Saxon** forefathers, need never lack opportunities of combining their knowledge of history and their studies of geography, and thereby not only increasing their knowledge of both, but learning much that is pleasant, much that is interesting about the scenes

* The Rev. J. C. Atkinson, Vicar of Danby, quoted in "Filey and its Church," by A. N. Cooper.

† It is said that in a small village in the neighbourhood of Nottingham women are still accustomed to threaten their children with the coming of the famous Black Raven, the crest of the Danish chief Ragnar Lodbrog, who occupied the neighbouring fortress of Nottingham, one of the five towns of the Danelagh, and whose ill-omened emblem was hated and feared through the length and breadth of Mercia and Wessex.

and places with which they have all their lives been familiar.

One example will serve to show how history and geography may be made useful and pleasant companions to one another. Here is an extract from the Charter of

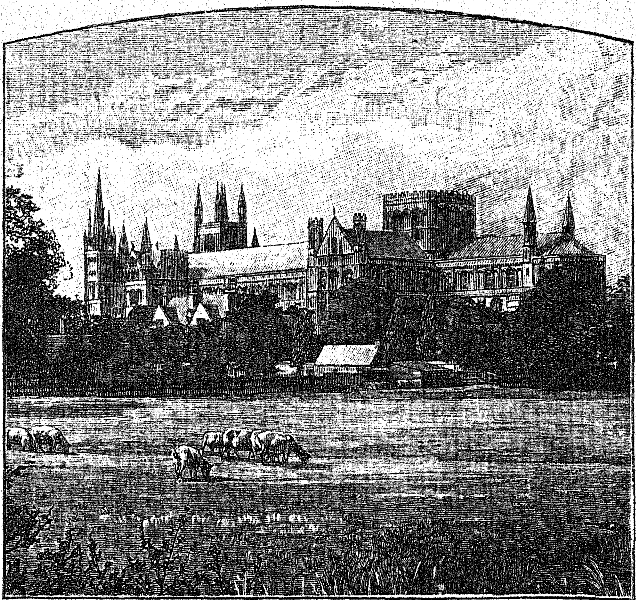


Fig. 95.—Peterborough Cathedral.

Gift to the **Abbey of Medeshamsted**, or **Peterborough**, a thousand years ago :—

"This is the gift from **Medeshamsted** to **Northburh**, "and so to the place which is called **Folies**, and so all "the **Fen** right to **Esendic**, to the place which is called "**Fethermuth**; and so on the straight way ten miles long to "**Cuggedic**, and so to **Raggewilh**; and from **Raggewilh**

"five miles to the straight river that goes to **Aehm** and "to **Wisbec**, and so about three miles to **Throkonholt**, "right through all the Fen country to **Dereword**, which is "twenty miles long, and so to **Cynate Cross**—and so "on through all the meres and fens which lie towards "**Huntendun Port**—through **Welmesford**, **Clive**, **Aestun**, "**Stanford**, and from **Stanford** as the water runs to the "aforesaid **North Burh**."

This is, indeed, a familar enumeration. It is true we have not any longer Medeshamsted, but the stately Cathedral of Peterborough still stands upon the ground that was first consecrated by a Saxon bishop in the days of Peada or Edgar.

Northborough exists now as it did in the days of Wolfheir. We have no Raggewilh, but **Rothwell** marks its place. The Great Northern Railway runs through **Wisbeach** and **Huntingdon**. Clive, in its old form, is forgotten, but in its newer form of **King's Cliffe** is still familiar to us. Olm has given place to **Elm**.

Throkonholt survives as **Throkennolt**.

Dereward, in the Fens, is still to be found in the Fens as **Dereworth**. Grate Cross is **Great Cross**, Welmsford is **Walmsford**, Aston we know as **Aston**, and Stanford, with the change of a letter, has come down to us as **Stamford**.

It is true that these facts are more strictly connected with history than with geography; nevertheless they do undoubtedly tell us with absolute certainty that the Saxon and the Saxon rule were formerly established in the 10th century * in these eastern counties of England. And this is the kind of evidence upon which we have to rely in tracing the history of the expansion and movements of nations in every quarter of the globe.

* The Abbey of Medeshamsted was built by Peada, king of the Mercians, in the 9th century; rebuilt by King Edgar, 971.

Summary.

1. History and geography are closely united.

2. A knowledge of history gives special interest to the study of geography.

3. Many historical changes and movements depend upon geographical condition.

4. Examples may be found in—
   (*a*) Lombardy,
   (*b*) the Basque Provinces,
   (*c*) Finland and Hungary.

5. Examples may be found near home in—
   (*a*) Wales and Cornwall,
   (*b*) the northern, or Danish portion of England,
   (*c*) the southern, or Saxon portion of England.

CHAPTER XVIII.

POLITICAL GEOGRAPHY.

VERY closely connected with that branch of the study of Geography which we have spoken of as Historical, is **Political Geography.** At the present day, each state and country throughout the world has its frontier more or less clearly and certainly laid down, and its Government claims authority over a certain territory, the form, size, and position

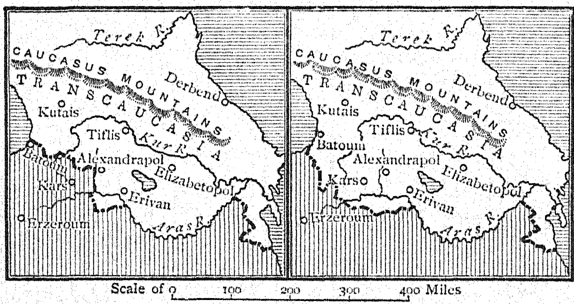


Fig. 90.—The Russo Turkish Frontier before and after 1876.

of which we can learn by looking at the map. But if we go back only twenty years, we shall find that the maps of to-day do not correctly represent the state of things which existed twenty years ago.

Changes of Frontier—Batoum.

Let us take one or two examples. If we look at the map which includes the eastern end of the Black Sea, we shall

find that the frontier between **Russia** and **Turkey** is marked as running from the sea coast, and that **Batoum** and **Kars** are marked as being in Russia; but the map of 1876 would have shown us the frontier in quite a different place. Batoum and Kars were then both Turkish, and it was not until Turkey had been beaten in the war of 1876-77 that this strip of Turkish territory fell into the hands of Russia.

Strasburg.

Again, to come nearer home. At the present moment, the city of **Strasburg** and the town of **Kehl**, which lies on the east side of the Rhine opposite to Strasburg, are both

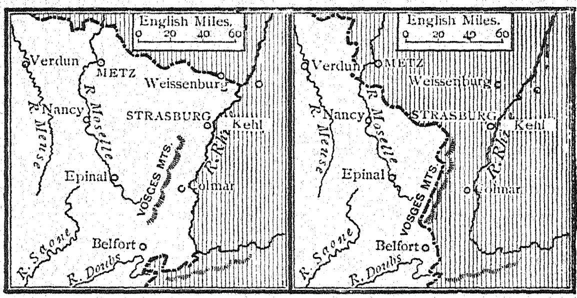


Fig. 97.—The Franco-German Frontier before and after 1870.

of them German. The German flag floats on both sides of the river, and German soldiers garrison the fortresses. One and twenty years ago two sentries met every day upon the bridge between Kehl and Strasburg—one was *French* and the other *German.* The French tricolour floated on the Cathedral of Strasburg, and the Prussians occupied the town of Kehl. The great war of 1870 made a tremendous change in the political geography of France and Germany, and not only the city of Strasburg, but the great wedge of country which runs into the north-east corner of France, and is made up of the province of **Alsace** and **Lorraine**, passed

from France to Germany. And while, even within the last twenty years, great changes have been made in the political geography of the world by war, changes scarcely less important have been made during the same period by peaceful means.

Bechuanaland and New Guinea.

In the southern part of the great continent of Africa, the enormous territory of **Bechuanaland**, a country nearly as large as France, has become part of the British dominions, and is being rapidly colonised and occupied by colonists from all parts of the United Kingdom. The island of **New Guinea**, in the eastern seas, has been divided between Great Britain and Germany, while seven great districts, **Arizona, Idaho, West Virginia, Montana, Nebraska, Wyoming**, and **Alaska,** have become States of the American Union.

Ancient Examples.

And if we go back, not twenty years only, but for the whole period of which history gives us any record, we shall find ample material for the study of political geography. We shall trace the rise and fall of the Greek states; we shall see how **Athens** and **Sparta** extended their influence over the other states of Greece. We shall see how the various empires of **Assyria** and **Persia** and of **Macedon** rose and fell, and how in their rise they extended their influence and their institutions over large portions of the earth's surface. We shall find traces of the conquest of **Alexander** in India and Persia, and his name commemorated in the city of Iskanderun.

Rome.

Then we shall note how gradually the rising power of **Rome** spread through Italy, along the Mediterranean, and

northward through France and Germany, till at length it reached the shores of **Britain** "remote from all the world."*

We shall see how Greek and Persian, Egyptian and Frank, German and Briton, were all in their turn compelled to give way before the splendid discipline of the Roman

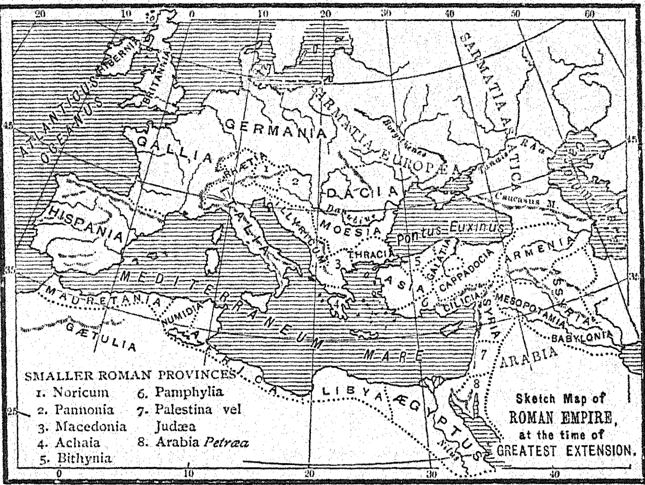


Fig. 98.—The Roman Empire in the Time of Trajan.

legions, and we shall come to understand how it was that a map of the known world in the year 100 A.D. is but another description of the Roman Empire.

The Making of the Nations.

Then again we shall see the gradual decay and breaking up of this empire, the rise and fall of many kingdoms, and with their rise and fall, their extension over and withdrawal from the territory which they claimed; the making of **England** and the making of

* "Penitus toto divisos orbe Britannos."—Virgil.

France, the creation of the **United States**, and in our own day, the making of **Germany**, will all come under our notice, and if we read our history intelligently with our map in our hand, we shall see how closely the affairs of a State are bound up with, and depend upon, the character, extent, and position of the country which it occupies, which it claims, or which it has conquered.

And here once more, as in every chapter of this book, we shall find that the lessons which the history of the world affords may be learnt and illustrated without going outside the island in which we live.

The Political Map of England.

Moreover, unless we know something of the political geography of England, we shall know very little of the country to which we belong, or of the people of whom we form a part. Twelve hundred years ago, the political map of England, if there had been anyone skilled enough to draw it, would have appeared full of divisions, each division marking a separate kingdom, and the kingdoms themselves peopled in many cases by men of what was then a foreign race.

Centuries of struggles, of fighting, and treaty-making, of invasion and settlement, were to pass by before the lines of division could quite be struck out of the map. Then when an English king at length reigned from Berwick to Penzance, the map-maker would have had to add to the dominions of the English king a broad tract of the lands of France, and the whole of Ireland. The map on page 253 shows the limits of the dominions of Henry V. (1413-1422).

A century later, and the historian tells us of Queen Mary dying broken-hearted at the thought that under her rule the last plot of French ground had been wrested from the English crown, and that **Calais** had fallen. The loss which Queen Mary mourned over was a blessing in disguise

to this country. For England to have ruled France would have been as impossible as for France to rule England, and the true strength of this country could never be used until we were free from a task which it was beyond our power to accomplish. Shut up within their native seas, the people

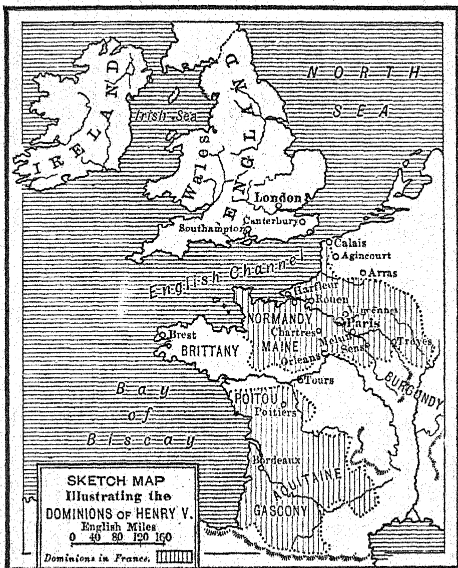


Fig. 99.—The English Dominions in the Fifteenth Century.

of England then turned their thoughts and their energies westwards, and under Queen Mary's great successor was founded on the American continent the famous colony called after the Virgin Queen—**Virginia.**

Another 200 years, and the colony of Virginia had become one of the **United States of America.** England, fighting for her life against the world, was unable to maintain her dominion over the colonists, and on the 19th September, 1776, the *Declaration of Independence* was signed,

which was to be the beginning of a second great English-speaking people.

Political Geography in Canada.

Meanwhile, on the same continent, our kinsmen in **Canada** were holding their own, through fair weather and foul, in splendid allegiance to the old country and the old

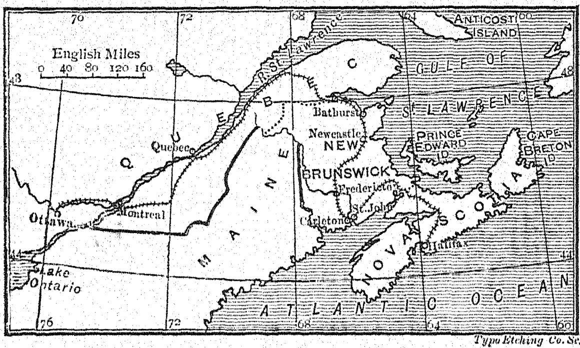


Fig. 100.—Map illustrating the Error of the Ashburton Treaty.

flag; and maintaining their territory first against France and then against the United States.

And the history of Canada recalls one very striking example of the connection between politics and geography.

For a long time there had been a dispute as to the proper boundary between the Canadian province of New Brunswick and the **State of Maine** in the United States.

It was decided to put an end to the difficulty once for all, and a British diplomatist, Lord Ashburton, was sent out in the year 1842 to make arrangements with the American Government, and to settle the frontier by a treaty. The treaty was made, and by it the frontier, as we see it on the map, was settled. One can see at a glance that the way in which the frontier line is drawn is most

disadvantageous to Canada, most fortunate for the United States. The direct road from **Montreal** to **Halifax** is now straight through the State of Maine; and in order that a Canadian may get from the one place to the other without leaving his own country, he must go far north and then come down again to **Carleton** (Fig. 100). The proper frontier would, of course, have been a straight line from **Ottawa** to **Carleton.**

It is said that this very bad arrangement was simply the result of the British representatives not knowing the geography of the country about which they were making the treaty; and that the Americans, better informed as to how the land lay, stole a march upon us, and persuaded Lord Ashburton to sign the treaty, which has, as we see, so terribly disfigured the Canadian frontier line.

Political Boundaries.

There is no end to the instances in which geography and politics are bound up together. It is under this head that we may fairly put all questions which arise when a geographical boundary is also an important political boundary, or where a certain division on the map marks the limits within which a particular political party is powerful, a particular set of opinions prevails, or a particular grievance is felt.

It is easy to think of examples of this kind. To begin with, anyone who knows the boundaries of the divisions which elect county members to Parliament must have made a pretty close study of one branch of political geography.

But if he only knows the actual divisions as they are marked upon the map he has only completed half his task. As a rule, it will be found that each division has a particular character depending upon its geographical position, the nature of the soil, and the occupations to which it gives rise. Thus, as a general rule, the views and character of a

number of voters who live in an agricultural district will differ on many points from those of voters who live in a mining district. The views of the miners will again differ from those who live in large towns. Where there is a large population speaking Welsh, there will probably be a population who hold particular views on Welsh questions. Hence it is important to know which are the **Welsh-speaking** districts and counties, and where the Welsh-speaking population is the thickest. Again, in Ireland, there are points upon which the **Protestant** population differs from the **Roman Catholic** population; and this difference of opinion has often had important political results. It is therefore necessary for any person who wishes to take a correct view of Irish politics to study the geography of the country, and to learn which districts are Protestant and which are Roman Catholic.

Political Geography of Italy.

All over the Continent there are plenty of opportunities for studies in political geography. To take a single example, we may turn to the kingdom of **Italy**, where the question of political geography is a very important one. Up to the year 1861 there was no kingdom of Italy, and Italy was divided into a number of small kingdoms—principalities, dukedoms, republics, and so on—which had no head, and which, by reason of their divisions, had no strength. A great part of Italy was in the possession of a foreign Power. The **Austrians**, who had conquered a great part of the country in former wars, still kept possession of the famous city of **Venice**, and of a large piece of country in the north-east corner of Italy.

To this country, and to a great deal more, the Italians laid claim. They said that the people who lived in the country which they claimed were Italians by race, by language, and by their love for Italy, and that some day these districts must be set free or *redeemed* from the power

of their conquerors, and made part of United Italy. "Unredeemed Italy" or "**Italia Irredenta**," was the name by which these districts were known. In the year 1859, the French sent an army into Italy to help the Italians, and having beaten the Austrians in the two great battles of **Magenta** and **Solferino**, they drove them out of the greater part of Northern Italy.*

In 1866, when Austria was at war with Prussia, the Italians took the opportunity to try and get a further portion of "Italia Irredenta," and, though they were defeated by the Austrians at the battle of **Custozza**, they managed, by making use of the victories of Prussia, to get their old enemies out of the longed-for territory of Venice.

Unredeemed Italy.

But even now the Italians have by no means finished their study of political geography. Some of them say that there is still a great piece of **Unredeemed Italy** left which ought to be joined to their country. Some of the Italian school books have chapters upon the "**Irredenta**," and the writers claim that a great part of what is now the Austrian province of the **Tyrol**, the town of **Trieste**, and a portion of the coast of **Dalmatia**, now belonging to Austria, ought to be Italian. Nor is this all. **Tunis**, in Africa, is claimed as part of the Irredenta, and so also is our island of **Malta**.†

* It must be noted, however, that, although the French helped the Italians, they also helped themselves pretty freely. At the close of the war the Emperor Napoleon III. persuaded Victor Emmanuel, then King of Sardinia and afterwards King of Italy, to hand over to him the two Italian provinces of Nice and Savoy, which have ever since belonged to France.

† France has now got possession of Tunis, and as the French do not take the same view of the political geography of the Mediterranean, it is hardly likely that this particular part of the so-called Irredenta will become part of Italy. As to Malta, the writers of the Italian

It will thus be seen that the Italians have pushed their study of political geography very far, and that it is one of very great importance to them.

Dixon's Line.

One more example of the value of a study of political geography will be sufficient.

Between the years 1861 and 1865 was fought the great "War of Secession" in the United States, between "North" and "South." It soon became clear that the great question which the war was to decide was whether negro slavery should or should not continue to be lawful in the United States. Over and over again, in reading the history of that time, we come across references to "*Dixon's Line.*"

Where and what was "Dixon's Line?"

In the year 1764, when what are now the United States still formed part of the British dominions, a dispute was going on between Lord Baltimore, the Duke of York, and William Penn, who had received royal grants in Maryland and Pennsylvania, as to the true boundary between those states. Two English engineers, **Mason** and **Dixon,** were appointed to go into the question and to draw the boundary. They carried out their instructions, and the frontier as laid down in 1764 has ever since been recognised, and has been known as "Dixon's Line." But it was not till nearly

school books have studied their political geography more by the light of their own hopes and wishes than by the light of history. Malta is in no sense part of Unredeemed Italy. It never belonged to Italy since the days of the Roman Empire, and the language of the Maltese is not Italian. We took Malta from the French in 1800. The French took it from the Knights of St. John in 1798, who in their turn had received it 268 years earlier from Charles V. Malta is part of the British Empire, and will remain so.

a century later that "Dixon's Line" became famous. It then became known to all the world, because it was the dividing line between the Northern States, which had abolished slavery, and the Southern States, which permitted it. A slave who crossed "Dixon's Line" was free, and the law forbade his recapture when once he was north of "Dixon's Line." *

It is easy to imagine what must have been the importance to a fugitive slave of a knowledge of this piece of political geography. On one side of the line was slavery, on the other side was freedom. And later on, when the question of slavery or no slavery had roused men's minds and excited their passions, there broke out the great War of Secession between North and South, which was carried on with the fiercest courage between the two great parties in the United States. And when the war broke out the boundary between the northern and southern states naturally came to be this same Mason and Dixon's line, which separated the Free State of Pennsylvania from the Slave State of Maryland. Whenever we read the political history of a country, we shall only half understand it unless we study its political history with a map in our hand, and get a clear idea of its political geography.

SUMMARY.

1. Geography and politics are closely connected.

2. Political frontiers often depend upon geographical frontiers.

3. Changes in political geography play an important part in the study of history.

* This was the upshot of the *Missouri compromise*, an arrangement by which Mason and Dixon's Line was agreed to as the boundary between the Northern Free States and the Southern Slave States.

4. Examples of the connection between politics and history may be found in—

(*a*) Turkey,
(*b*) Alsace Lorraine,
(*c*) Bechuanaland,
(*d*) and in ancient history in Greece and the Roman Empire.

5. The political map of England furnishes many examples.

6. Political boundaries depend upon many considerations, such as geographical situation, population, general tradition, etc.

CHAPTER XIX.

MILITARY GEOGRAPHY.

War and Geography.

THERE is probably no profession in which a knowledge of geography is so necessary and so useful as in that of the soldier. Ever since battles have been fought and campaigns planned, the fortunes of the combatants have, in a very large measure, depended upon the nature of the ground on which they fought, the character of the country through which they moved, and the geographical difficulties they had to encounter in arriving at the places they wished to reach.

It has been said that in the great war of 1870 between France and Germany, the Germans knew the geography of France better than the French themselves; and there can be no doubt that every step of the campaign, from the time when the German troops were first called from their homes to the time when they arrived before Paris, was studied long beforehand, and prepared by the chiefs of the German army.

Where Battles are Fought.

It scarcely ever happens, indeed, that a battle is fought in a place fixed quite by chance. It generally happens, on the contrary, that the spot on which the battle takes place is one which was settled long beforehand by the geography of the country. This may seem at first sight rather an exaggerated statement, but a very little examination of the circumstances which have preceded the greater number of battles which are famous in history will show us that it is true.

Examples from the Elbe Valley.

When **Prussia** went to war with **Austria,** in 1866, the Prussian armies marched through the city of **Dresden,** and up the valley of the **Elbe** southwards towards **Vienna.** More than fifty years earlier, in 1812, when **Napoleon Buonaparte** was attacking the Austrian army coming from **Vienna,** another series of great battles was fought on the same line of the **Elbe.** And earlier still, at the end of the eighteenth century, when the Austrians, in the reign of **Maria Theresa,** were attacking the Prussians under **Frederick the Great,** they also marched through exactly the same gorges of the **Elbe** from south to north.

The reason why, in three different periods of history, the same spot became the scene of so many battles is not far to seek. All round the **Kingdom of Bohemia** runs a chain of mountains which separates it from Saxony and Prussia on the north and from Austria on the south. Through these mountains, between **Bodenbach** and **Dresden,** the river Elbe cuts its passage, making a great thoroughfare from south to north, through which the railway line from **Vienna** to **Berlin** runs. The railway line takes this course because it is the easiest and the most natural course to take. For the same reason the Austrian armies entering Prussia, and the French and Prussian armies entering Austria, have also taken what was the easiest and most natural route. As a consequence, we find that battle after battle has been fought either in the gorges of the Elbe, or a short distance beyond them to the north or south. A glance at the map will show how close to one another the battle-fields of the different campaigns lie.

North Italian Battles.

In the same way we find that the north of Italy is covered with battle-fields, but there is not one of them which does not owe its position to some geographical reason.

Round the northern part of Italy runs the great chain of the Alps, with passes or crossing-places over it at intervals. Such are the well-known Passes of the **Simplon**, the **St. Gothard**, and the **Brenner**. From the Alps there runs down a series of rivers, flowing from north to south. All these rivers cross the plain of **Lombardy**, which stretches

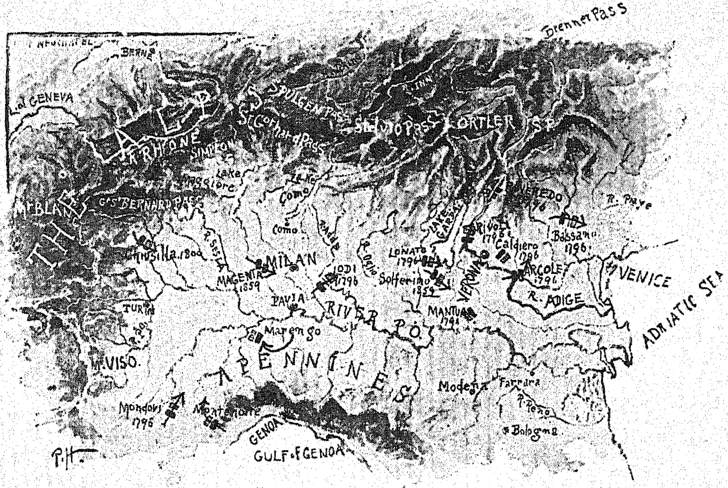


Fig. 101.—Map illustrating Italian Campaigns.

out at the foot of the Alps, and empty themselves into the **Po**, which runs from west to east into the **Adriatic Sea**.

If we examine the battle-fields of Northern Italy we shall find that the position of almost every one of them can be accounted for in one of two ways. Either an army having crossed one of the Alpine passes has had to fight a battle *while descending from the pass*, or *just after arriving at the foot of it;* or an army, while moving from east to west, or west to east across the plain of Lombardy, has fought a battle to *win or to defend a passage across one*

of the rivers which run from north to south. Of the former character were the battles of **Montenotte**, **Mondovi**, **Lonato**, and **Rivoli**, in 1796, and of **Chiusilla**, in 1800. Of the latter character were the battles of **Lodi**, **Borghetto**, **Bassano**, and **Arcola**, in 1791; of **Marengo**, in 1805, and of **Magenta** and **Solferino** in 1859. [19]

An examination of the map (Fig. 101) will serve to render clear the main outlines of the movements which preceded the battles which have been chosen as our examples in this chapter.

One place in particular in the whole range of the Alps seems specially made for the passage of armies. This is the valley of the Adige, which, as you will see in the map, goes far back into the mountains, and offers an easy road from Italy into Austria. Over and over again, armies passing, or trying to pass, from Italy into Austria, have entered upon this road, and all along it we see traces of their struggles on the battle-fields of **Mantua**, of **Caldiero**, of **Rivoli**, and of **Roveredo**.

Military History and Geography.

Few branches of geography are more interesting than that which deals with military history. But there is not space here to discuss the principles of the science of Military Geography at great length. One or two main facts, however, we may remember. In the first place, the general principles of military geography always remain the same. Yet the particular form in which those principles apply changes from time to time.

It is said by military writers that *the worst frontier*, and the frontier which is the hardest to defend, *is a river.* A little better is a *thick chain of forest.* Better still is a *range of mountains*, or the *sea.* And best of all is a wide expanse of *desert.* No doubt military writers are quite correct in this matter, but it must be remembered that a river, which

is no obstacle at all nowadays, when the methods of making bridges are greatly improved, often proved a most serious obstacle in days gone by. Again, the sea was far more of a defence in the time of sailing vessels than it is now in the days of steamers. In the days when every ship had to beat up through the Straits of Gibraltar under sail in order to pass from the Mediterranean into the Atlantic, or *vice versâ*, the position of Gibraltar was of great value from a military point of view. Now, however, when steamers can always pass up and down the Straits at any hour of day or night and at any distance from either shore, the value of the fortress has been greatly diminished.

So, too, in the case of the desert, which in these days of railways may be crossed in a few hours instead of the days which were formerly required. The great difficulty which meets an army in crossing a desert is the want of water for man and beast. The length of the march must be regulated by the distance between the wells at which water can be obtained; and where there are neither wells nor springs, water must be carried by the troops sufficient for themselves and for the animals by which they are accompanied. A delay of a couple of hours in the day's march may mean the loss of scores of men and horses, who are unable by nightfall to reach the longed-for water supply. The loss of the water carried by the advancing column may mean death to every man in it. It is easy to see, therefore, what a terrible obstacle a desert may present when science has done nothing to overcome the difficulties which it offers. But when the railway has once bridged the waterless plain the difficulty is gone.

Thus it has been in Northern India, where the desert which lies between the River Indus and the great **Bolan** Pass in the Himalayas was till a few years ago an almost impassable barrier between our Indian Empire and the portion of Afghanistan into which the

Bolan Pass descends. In the year 1879, however, our engineers undertook to carry a railway across the desert. The difficulties were great, the sufferings of the workmen from want of water were very severe, but, nevertheless, the work was pushed on with extraordinary rapidity. In 101 days no less than 133½ miles of rail were laid down. And now the trains run without interruption across the level plain from **Sukkur** to the mouth of the **Bolan Pass**. So far from being an obstacle to our advance, the smooth surface of the desert affords an easy and rapid line of approach to our posts on the northern side of the Himalayas. So also in the great plains of Central Asia. The deserts which at one time were considered to be impassable by any army, have been used by the Russians as supplying a level course for their new railways. Already trains run without difficulty from **Krasnovodsk** on the Caspian Sea to **Samarkand**. There can be little doubt that before long a line of railway will cross the continent of Asia from the Ural Mountains to the shores of the Pacific, and that the desert will everywhere be made to connect instead of separating neighbouring countries.

Methods Change but Principles Remain.

Thus we see that though in all ages geography has had a great deal to do with the course of military history, it is not true to say that the same geographical circumstances have always produced the same military results.

In our own country we have had many wars, but the particular places which were most important from a military point of view 300, 500, or 1,000 years ago, are not in all cases of the same importance now.

A Disputed Frontier Abroad.

Happily, moreover, England has been so free from wars within its borders of recent years that we have had but

little occasion to study the military geography of our own land. But the same principles which apply to military movements in other parts of the world applied in former days to England. It is absolutely necessary for those who command the armies of Germany and France to study the geography of the frontier between their respective countries, for they do not know what a day may bring forth, and are ever expecting that the storm of war may be let loose upon the **Rhine** or the **Vosges.**

A Disputed Frontier at Home.

A similar fear once filled the minds of those who directed the government of England at a time when there was more than one hostile country within the limits of what is now the United Kingdom. If we go back 1,500 years we find the Saxon conquerors of our island at fierce war with the Britons whom they had driven back against the west coast. There were two great divisions of the Britons, one occupying the kingdom of **Strathclyde,** which stretched from the Clyde to the Dee; the other occupying what is now the principality of **Wales.** Between these two provinces, or kingdoms, and at the junction between them, the River Dee flows into the Irish Channel, and situated at a point where the river narrows to a breadth which can easily be crossed, lies the city of **Chester.** One of the fiercest fights which took place between Saxon and Briton was the fight which befell under the walls of Chester in the year 607, and which resulted in the defeat of the Britons by the army of **Æthelfrith** King of Northumbria.

From the time of the battle for many years onwards, Chester was held as a fortress, thrust in between the Britons of Strathclyde and the Britons of Wales, and no communication could take place between those two provinces save at the risk of passing before the walls of **Chester.** Now the North-Western Railway runs from Chester northwards through

Warrington to Carlisle in Strathclyde, and westward through Bangor and Carnarvon to Holyhead in Wales. The necessity for maintaining Chester as a fortress is gone, but a glance at its position on the map will show how plainly it was marked out by the geography of the country for the work it had to do.

The Ford of the Medway.

There are very few fortresses in England, for we are content to rely almost entirely upon the sea for our protection. But of the few strong places which we have, **Chatham** is one of the most important. If we travel from London to Dover by the London, Chatham, and Dover Railway we shall see as we approach the town the low smooth outlines of the modern forts on the tops of the outlying hills; and, as we come in sight of the town itself, the first object that catches the eye is the great square mass of **Rochester** Castle.* Rochester Castle, built by the Normans, served in its time the same purpose as the grass-covered forts of our own day are intended to serve. It defended the passage of the River **Medway**, and closed the road to London against an enemy marching from Dover, or from any of the seaports on the coast of Kent.

Nor were the Normans the first to find out the value of Chatham as a military post. As, long before the battle of Chester, the **Romans** had built a fortress at the mouth of the **Dee** and called it **Castra**, the **Camp** (corrupted into Chester), so the same keen-eyed race of soldiers had fixed upon the ford of the Medway as the site for one of their first strongholds, and the name of **Rochester** *still preserves* for us a testimony to their wise judgment. The Romans came, made their mark, and left our shores. Another invader followed in their steps, and he, too, made

* The three towns of Rochester, Stroud, and Chatham are all joined together by a single long street, and form in reality one town.

haste to seize the all-important point. It was within a few miles of the spot where the railway bridges now span the river that one of the earliest battles recorded in our English history was fought. In the year 449, **Hengist** and **Horsa,** landing with their Saxon followers on the coast of Kent, marched west upon London. They reached the ford of the Medway at the spot where Chatham now stands. But the place of which they were so anxious to take possession the Britons were as determined to keep, and the fortifications which had been erected to guard the ford checked their advance. They turned southwards, marching up the river in the direction of Maidstone, and attempted the passage of the river. The battle that was fought was long and bloody, and the Saxon chief, Hengist, fell in the assault; but the ford was won, the fortifications of Chatham were turned, and the enemy had opened the road to London.

And thus it will be seen that, both at home and abroad, we shall find plenty of material for the study of **military geography**, and that indeed no military campaign, whether ancient or modern, can be understood unless we make ourselves acquainted with the geography of the war.

Summary.

1. A knowledge of geography is necessary in pursuing the art of war.

2. Warlike operations are almost always dependent upon geographical circumstances.

3. The influence of particular geographical conditions upon war varies in different periods of history. What was an obstacle to an army in one age ceases to be so in another.

4. Military geography may be usefully studied in the United Kingdom.

CHAPTER XX.

COMMERCIAL GEOGRAPHY.

The Connection between Commerce and Geography.

Commercial Geography, as its name tells us, is that part of the science of geography which is of special service to those who are engaged in *Commerce.*

As we said in an earlier chapter, there are many ways in which we may look at a thing, and if we look at the earth as the source of all the various commodities which we require for food, for clothing, and for manufacture of every kind; and if we look at its surface, its continents, and its seas as roads over which these commodities may be brought to the spot at which they are required, we shall then be looking at the earth from the point of view of a student of Commercial Geography. There are a great many matters which might very well come into this chapter, but if we were to try and deal with them all, the chapter would soon run to the size of a very thick book.

But it is possible to put into a short space some of the most important points which arise in the study of commercial geography.

Where, and of what Quality?

Any person who is about to engage in commerce must turn his attention to one or two special questions, to which he must get an answer before he can expect to conduct his business with any success. He must know in the first place *where the articles which he wishes to buy or exchange are to be found*, and not only that, but he must know where they are to be found in the *largest quantity and of the best quality.*

But when he has learnt this, he will still have much more to learn. It is quite possible that there may be a large amount of some particular article of a very good quality which is of little or no use to the merchant because it is in a place from which it can only be brought at a great cost or with great danger. The merchant will therefore have to inquire what are the means of bringing his goods to market; and, when he comes to make these inquiries, he will often learn other things which will alter the course of his business, and which will enable him to conduct it at a greater profit than would otherwise have been the case. He may learn, for instance, that the persons who are engaged in growing the crop that he requires, or in raising the minerals which he wishes to sell, are in need of some special article which he can supply, and thus he will be able to make an exchange favourable to himself.

Or it may turn out that the materials which are necessary for carrying on his works are to be found upon the spot, and thus he will be saved the necessity of sending them out at a great cost from his own country. These, and a great many other questions of the same kind, present themselves to persons who engage in commerce, and the better the merchant is acquainted with the answers to them, the better is he likely to succeed in his business.

It will be best, in order to understand what has just been said, to give a few examples taken from the actual facts of modern commerce.

Distribution.

A most important part of commercial geography consists in a knowledge of the **distribution** of various commodities over the earth's surface. Such a knowledge is of great value to those who possess it, and often has very important results. Our own country presents us with a very early example of the advantage which arises from a knowledge of the distribution of commodities. It is over 2,000 years ago that

the Phœnicians discovered that in the **Cassiterides**, our own **Scilly** Islands, were to be found deposits of tin, and hence it was that, as the first pioneers of the Mediterranean nations, they passed through the Straits of Gibraltar, crossed the Bay of Biscay, and landed on the Scilly Islands and on the coast of Cornwall. We may be sure that their enterprise, and their prompt use of the knowledge which they had obtained, were rewarded.

For many hundred years the tin mines which they had opened were among the principal sources for the supply of this metal throughout the world.

In later days other commercial peoples have followed the example of the Phœnicians, and having discovered that tin was to be found in still greater abundance in other parts of the world, have started the great tin mining industries of **Bohemia, Saxony, Spain,** and the **Malay Peninsula.**

The Distribution of Iron and Coal.

There is scarcely any important part of the world where **iron** has not from time to time been discovered; and when iron has been found, the next task has always been to endeavour to find **coal** in the neighbourhood; for the value of iron without coal to work it is very much less than that of iron in the neighbourhood of a good coal-field. Hence it is that in our own country the manufacture of iron has grown so greatly and prospered so much. The coal and the iron lie side by side. And yet, though this be true enough, the fact, as it has just been stated, is not only a good lesson in commercial geography, but is an example of the danger of jumping to conclusions in this or any other matter.

As a matter of fact, Great Britain still holds its place as one of the greatest manufacturers of steel and iron; and it is true that she first took this place at a time when the coal which lies in our native rocks was worked to forge the iron which lies beside it. Now, however, the greater part of the

iron which is manufactured in England comes not out of our own rocks, but is brought in from abroad from Sweden and from Spain.

When we come to deal with that part of this subject which has to do with "carriage and transport," we shall understand how it is that this comes about, and we shall see that after all, the iron ore of **Bilbao** is as near for the purposes of the manufacturer to the iron foundries and coal-fields of South Wales as are the ironstone beds of Derbyshire.

How Iron was Worked 200 Years Ago.

And while we are speaking of this question of iron and iron working, we may recall yet another instance of the connection between geography and commerce.

It was not till the end of the seventeenth century that the use of coal (sea coal as it was then termed) for working iron was known and practised in this country, and the fuel used up to that day was charcoal. Iron was heated in the charcoal furnaces, and wrought and beaten by trip hammers worked by water-power. Hence it came about that it was in those parts of England where underwood suitable for charcoal-making was most abundant that the greater part of the iron forging was done, and it was in the midst of the copses of **Kent** and **Sussex** that our chief English smithies and foundries were situated. All over these counties we constantly find the name of "**Hammer**," indicating the place where the old iron foundry used to be.

But when coal came into general use for iron working, the whole industry migrated to the north and to the midlands, and to the neighbourhood of the coal measures.

Climate and Commerce.

A study of **climate** and its effects is also a very important part of commercial geography.

In the first place, the amount of work which a man can

do will depend greatly upon the climate of the country in which he is to work. In many parts of the tropics it is almost impossible for white men to undertake regular labour, and natives accustomed to the great heat must be employed under the direction of white men. In the northern part of Australia, especially in **Queensland**, the northern boundary of which is in latitude 10° 40′ S., the difficulty of getting Englishmen to work is very great, and many attempts have been made to get over it by importing Chinese or Indians to cultivate the sugar cane and other plants which form the riches of the country.

Again, there are countries or portions of countries which, from their position and from the character of the vegetation which covers them, are very unhealthy, and in which persons not accustomed to the climate are almost certain to fall ill and become incapable of work.

Those who engage in commerce with such a country, or who endeavour to start a trade or manufacture in it, must take into account the danger from disease, must know what seasons it is most often fatal, must inquire what are the drugs and what is the treatment by which it can be met, and what are the chances of removing the causes of sickness.

Turning from the hot countries to the cold countries, it is often equally important to have accurate information as to the climate. Recently an attempt has been made to open up commerce with the Russian territories in the north of **Siberia** by means of steamers from London to the mouth of the **Yenisei River.** The mouth of this river lies in latitude 70° N., or only 20 degrees from the north pole, and it was unknown to the explorers whether the navigation were blocked by ice all the year round, or whether there were sufficient open time during the summer to enter the river. It was discovered that for a short space during each year the water was open, and though up to the present time the

results hoped for from the expedition have not been fully achieved, there can be little doubt that the knowledge which has been acquired of the condition of the climate between **Spitzbergen** and the mouth of the **Yenisei River** will be of great use in the future to those who desire to open up trade with the north of Asia.

Climate and Corn-growing.

Connected with the question of climate are such matters as rainfall, the date and duration of rainy seasons, the character of the soil, the nature of the vegetation—all these must be studied by any person who hopes to have a full acquaintance with the commercial geography of any country. There is still much to be learnt with regard to such matters, but during the last few years great additions have been made to our knowledge in regard to many points. Among other important discoveries is that which has enabled us to turn the great **North-West of Canada** into a vast and productive corn-field. It was believed at one time that the severe Canadian winter, during which the thermometer often falls 40 degrees below zero, must prevent the successful cultivation of **wheat** in the districts north of the great lakes which separate Canada from the United States. It has been found, however, that this is far from being the case, and that what is really necessary for the proper ripening of wheat is a sufficient amount of bright warm sunshine during a short period in summer. Such a time of sunshine can always be relied upon in Canada, and in consequence it has been found possible to utilise thousands of square miles in latitude 60° North for the growth of wheat. No less than 20,284,346 bushels of Canadian wheat were grown in the Dominion in the year 1888. It has been stated that the limit of wheat-growing has not yet been reached, and it has even been proposed to attempt growing wheat within the Arctic Circle,

in order that full advantage may be taken of the twenty-four hours' sunshine of the polar summer day.

It must not be supposed that we have done more than to suggest a few of the particulars which make a study of climate so necessary to anyone employed in commerce.

Thousands of other examples might be given if space allowed, but enough has been said to give some idea of the kind of questions to which a student of commercial geography should devote his attention. In this case, as in all others which have been referred to in these pages, our own country will furnish us with examples of the general truth which we have to examine.

Character Depends upon Climate, and Commerce upon Character.

We have already seen (p. 106) how greatly the people of England depend for their character and their occupations upon the climate in which they live, and we have seen also that climate may depend to a very great extent upon the course of the Gulf Stream, which brings its moisture and its warmth across the Atlantic to our shores.

It has been said by a humorous American critic that "England possesses no climate, but only a number of samples of weather." There is a good deal of truth in this description, but perhaps we are after all gainers from the fact that our climate possesses so many varieties, for there is scarcely an extreme of heat or cold to which an Englishman is likely to be exposed of which he has not had some sort of experience at home.

Although, however, it is true that there are occasions upon which very great extremes of temperature are reached in the United Kingdom,[20] it is probably fair to say that the most remarkable thing about our climate is its moderate and generally uniform character, which is on the whole favourable to health and permits of hard and

effective work being undertaken at all times throughout the year.

Carriage and Transport.

It is most important that the student of commercial geography should acquaint himself with the chief facts concerning the **carriage** or **transport of goods** from one part of the world to another. He must learn what are the **shortest,** and what are the **quickest,** what are the **cheapest,** and what are the **safest routes.** He must consider whether cheapness or rapidity is to be taken into account in bringing goods to market. He must find out what is the cost of loading and unloading in any particular place, and how many times it will be necessary to change from one kind of conveyance to another during the journey.

With regard to the various ways in which merchandise may be sent from one place to another, it may be said that there are two great divisions: **carriage by land and carriage by water.** To these of course may be added a third way, which is partly by land and partly by water. As an almost invariable rule, carriage by sea is cheaper than carriage by land, and the greater the distance to be traversed, the greater will become the difference in favour of carriage by sea.

Carriage by Land.

In ancient times nearly all carriage was by land. In the East the caravans passed backwards and forwards from Egypt as far as India, and to this day great **caravan routes** are still open, and are traversed in the same way as they were thousands of years ago. It need hardly be said that this method of transporting merchandise for long distances upon the backs of camels or horses, each animal requiring to be fed and cared for and to be looked after by attendants, who must in their turn be furnished with provisions, is very expensive.

A certain amount of fine tea is brought overland to Russia each year from China, and is known as caravan tea. The price at which it is sold often reaches twenty shillings a pound.

Throughout the whole of Western Europe, including our own country, the first great commercial roads were made by the Romans and were traversed by long strings of pack mules, and for many centuries mule or horse transport was the common method of sending merchandise overland.

In England there are many such pack-roads still to be seen. One of the oldest is the so-called Saxon Driftway, which runs across the Wiltshire and Berkshire Downs; the well-known Roman roads of Watling Street, the Foss Way, and the Icknield Way are other examples of those old lines of communication.

Carriage by Water.

But long before these slow methods of overland carriage had been replaced by stage coaches or railroads, the carriage of merchandise by water had become universal throughout the world. At first, no doubt, the simple plan of floating logs down a river with the current was all that was attempted; the logs were soon replaced by boats capable of moving up the stream as well as down it. From the mouths of the rivers adventurous persons put out to sea and coasted along the shore. At length, as the size of the vessels increased and the art of navigation became better known, sailors, taking their guidance from the stars, boldly sailed on the high seas out of sight of land and crossed and recrossed the Mediterranean and the Red Sea. By degrees the pursuit of gain and the love of adventures or the passion for war led the mariners still farther, and Northern Europe, Asia, and Africa all became familiar with the sight of sea-going vessels.

At length the introduction of the **mariner's compass** opened a new and still more important area to the seamen.

In 1498, **Columbus** sighted the shores of America, and from that day to this the fleets of ocean-going ships have increased, till at the present day the world's tonnage is reckoned at 19,341,000 tons.*

Canals.

Nor when we have spoken of rivers and the sea have we exhausted the means by which water carriage may be made available for the purposes of commerce. In our own day the making of canals has been attempted upon a scale hitherto unheard of. Already the waters of the Mediterranean and the Indian Ocean have been joined together by the genius of a great Frenchman, **M. de Lesseps**, and the day is fast approaching when a similar cutting will pierce the **Isthmus of Panama** and unite the waters of the **Atlantic** with those of the **Pacific.**

Steam.

One other great advance in the methods of conveying merchandise remains to be mentioned. The invention of the steam-engine has effected a greater change in the methods of transporting goods by sea and land than had resulted from any other invention during the period which history records. The beginning of this century saw the first introduction of the steamboat. The Stockton and Darlington Railway was opened on September 27, 1825, and from that time we enter upon an entirely new condition of things in respect to the carriage of goods. Day by day the locomotive and the steamer are reaching fresh points on the earth's surface. The great ocean steamers cross the Atlantic in less than seven days. Already four lines of railway connect the Atlantic and the Pacific, while in all probability in a few years' time a continuous line of rails will extend from **Brest**

* Of which no less than 7,444,000 tons are British.

on the Atlantic, 6,000 miles across two continents, to **Vladivostock** on the icy waters of the North Pacific.

The Effect of New Methods of Communication.

Let us see what has been the effect of the introduction of these new methods of conveyance, in what way they influence the arrangements of commercial men, and what is their value for the purposes of trade.

Let us take the case of a merchant whose central office is in London, and whose business it is to bring to market and sell on the most advantageous terms the products of distant lands. Whatever may be the nature of the enterprise in which he is engaged, it may be taken for granted that one or two special rules will always govern his conduct. *He will endeavour to bring the goods he has to sell to market, at the lowest possible cost to himself, and to sell them at as high a price as he can possibly obtain.*

In order to obtain a high price it is not always sufficient to offer the goods for sale. They must be put on the market at *the right time*, in *the right quantity*, and in *the right condition.* Moreover, the sale will depend upon the place which is selected for a market.

Bringing the Goods to Market.

We will imagine that the merchant has succeeded in buying the goods at a very advantageous price in the place where they are made, grown, or produced. He now has to bring them to market, and he must first consider how this can best be done. Before he gives an answer to this question he must decide *whether* **cheapness** *of transport or* **rapidity** *of transport is the more important to him.* The answer to this question will depend upon the character of the goods and upon the market for which they are intended. For instance, a large quantity of **wheat** is sent

from America to this country in sailing vessels, which take as much as from 3 to 4 months to go from San Francisco to London. Sending the grain by sailing ship and not by steamer is no doubt cheap, but, as we have seen, it is a very slow business. Nevertheless, in many cases the merchant will prefer the slow and cheap transport to the rapid and expensive one. There is a market for wheat all the year round, the grain is none the worse for its long journey, and it is sure to be sold when it arrives.

On the other hand, supposing the cargo to consist of **live cattle,** it is plain that rapidity is much more important than cheapness, for every day at sea diminishes the value of the cattle; some may die on the way, and not only are they certain to be a long time on the voyage, but contrary winds may detain them for many days after their arrival was expected.

Rail and Sea Transport Compared.

Again, if we come to compare transport by rail with transport by sea, we shall find that the cost of the latter is always lower than that of the former. It is important to understand how great this difference is. A ton of freight can be sent from San Francisco to London, a distance of 13,810 miles, for 40s. or about **3⅓d. per 100 miles;** but the average rate for sending a ton of goods by rail 100 miles in the United States, America, is as much as **5s. 3d.** It will be seen, therefore, that the cost by land is no less than **nineteen times** the cost by sea. And again, the cost for a ton of freight from Bombay to London, a distance of 6,300 miles, is **20s.**, or as nearly as possible **3¾d. for 100** miles, while the cost of sending a ton of coal by rail from Chesterfield to London, a distance of **161¼ miles,** is 6s. 8d., or 4s. 1¾d. per 100 miles.

It may be taken for granted that in all cases transport by water will be cheaper than transport by land, and hence

it is that such great efforts are being made to cut new canals and to enlarge existing harbours.

The Disadvantage of Transhipment.

As a rule, it is of course equally true that carriage by rail is quicker than carriage by water, though even this is not always the case, but is more especially so where the distances are short. It is not, however, always equally true where the distances are long. A large steamer goes straight upon her course day and night at a speed often reaching more than twenty miles an hour. A luggage train whose speed very seldom exceeds thirty miles an hour—and often does not reach twenty miles an hour—is subject to many delays, and is seldom able to travel in a perfectly straight course. Thus, for instance, there can be little doubt that merchandise sent by a fast steamer from **Hamburg** or **Bremen** to **Antwerp** or **Havre** would arrive at its destination sooner than if sent by a luggage train through Germany, Holland, Belgium, and France. On the other hand, there are many cases in which transit by rail will be more rapid than by water, and the merchant will then have to decide whether or not it will be profitable to him to incur the extra expense of the railway rate in order to obtain his goods at an early date. This will, of course, become a question of **profit and loss**, which he must work out.

When Quick Transit Pays.

As a rule, it may be laid down that it will pay to send **expensive articles** by the quickest route even though it be the most costly; the cost of transport will bear but a small proportion to the cost of the articles.

On the other hand, cheap **articles of great bulk** will depend very greatly upon cheap transport. For instance, for many years past a great deal of **wheat** has been grown in India, but none of it was ever brought to England, and

very little profit came to those who cultivated it. The expense of bringing it in carts to the coast was so great that by the time the corn had reached London or Liverpool, far more would have been spent in bringing it over than the buyers in the market would have been willing to pay for it. Of late, however, a number of railways have been made leading to the corn-growing districts of India, and by charging very low prices for conveying the corn to the sea coast, the railway companies or the Government, which in some instances has made the railway, has started a great trade in corn from India to the United Kingdom. The cost of actually bringing the corn from the place where it is grown to the English market is, it is true, greater than the cost of bringing an equal quantity from Canada or the United States. On the other hand, labour is very cheap in India, and the cost of raising the corn is less than in America, hence the advantage in the cost of growing balances the loss of the cost of carriage, and Indian growers are able to compete with their rivals in the London and Liverpool corn markets.

Changes in Manufacture.

Thus it will be seen that a change or improvement in the method of manufacture will sometimes take away a great industry from one part of a country to another, or from one part of the world to another part. The commercial man must study such changes, for it is sometimes in his power to bring about such a change for his own benefit. Thus he may find out that by turning to advantage the natural qualities of his own country, he may be able to carry on with great success some manufacture which has hitherto been carried on elsewhere by his rivals. For example, in the United States great efforts have been made to encourage the manufacture of **steel**, which, to within a few years ago, was almost entirely confined to

England. These efforts have been successful, and the whole of the steel for the ships of the American navy is now produced by manufacturers in the United States. Again, the discovery of some new process may often enable a manufacturer to produce an article which, before the discovery, could only be obtained from some distant place, and at a much greater expense. This has been notably the case in respect of many of the dyes which are used for colouring materials. The purple dye obtained from the plant known as **argill,** or **orgill,** is a good example. For many years argill was obtained from a plant of which large quantities were grown in the Canary Islands, and which formed the principal product in those islands. Not long ago, however, it was discovered that the purple dye produced from the argill plant could be obtained much more cheaply, and in larger quantities, from the common material known as "gas tar." Hence the whole supply of this dye now comes from manufacturing districts where coal and gas tar abound, and has been taken away from the Canary Islands; and many other of the dyes which are known as aniline dyes, and all of which are made from coal tar, have of late taken the place of colouring matters formerly obtained from distant sources and by expensive processes. The man who is first in the field in discovering and in making use of some new process of this kind will always have an advantage in the race for commercial success.

The Manufacturer must Suit the Customer.

Again, it is also necessary for those who are engaged in commerce to study the special needs and habits of those who dwell in other countries. It is particularly necessary that such a study should be made in England, for it often happens that in distant countries, such as China and South America, our merchants find that the goods which they make and send out do not please the natives because they

are made to suit English tastes, and not those of the persons for whom they were intended, and who have to use them.

English Merchants and their Rivals.

Thus, not very long ago, an English consul in China reported that the trade in tools and instruments of husbandry was passing from the hands of Englishmen to those of Germans, and the reason he gave was that English merchants would only supply tools of the same pattern as those which their countrymen at home were accustomed to use; but that the Germans, having studied the habits of the natives, offered them tools made in other patterns, which proved much more acceptable than those made to suit English workers. It is probable that the English tools were better than the German; but, as we all know, people in general prefer that to which they are accustomed, even though, by a change in their habits, they might obtain something which was likely to be better. It requires a very long time to alter the habits of any people, and of the people of China, who have had the same customs for thousands of years, this is particularly true. And the same reports have from time to time reached us from South America, where we are told that our rivals, the Germans, are readier than we are to supply what the people actually want, and not what they think the people ought to want.

The Germans, indeed, are very wise in this matter, and in the principal towns in Germany public museums have been erected in which are collected the products of every country, and also the articles which are in daily use among the people of these countries. By studying the wants of their customers, German manufacturers are able to supply them. We shall do well to learn from the Germans in this matter, and to follow and better their example.

A Lesson from Persia.

Sometimes the habits of one country have an odd effect in fixing those of another, and the following is an example which will show how easily a trade is turned into a particular channel, and how when it has got into that channel it remains fixed there. An English officer travelling some years ago in the **Persian Gulf** noticed that nearly all the houses upon the coast were of one pattern, formed of uprights joined together at the top by a slanting roof, each side of the roof being made by a single beam or plank. These houses varied very much in length, some of them being very long indeed, but the width of all of them was the same. What was the explanation of this strange architecture? It happened that the officer of whom we are speaking was very well acquainted with the coast of Africa in the neighbourhood of **Zanzibar**, and his knowledge enabled him to give an answer to the problem.

For many years there has been a considerable trade in slaves between the coast of Zanzibar and the Persian Gulf. The cargo of slaves, or whatever it might be, was carried in long narrow boats, and covered in by planks cut from the trees upon the coast, and fitted so as just to cover in the hold of the vessel. When the ships arrived in Persia the planks were taken and were regularly used by the builders for their house building, and hence it came about that the width of the Persian houses was exactly regulated for many years by the width of the Arab boats. This story has been told in order to show how strangely the customs of one country affect in an indirect way the customs and the trade of another.

The Effect of Local Customs on Trade.

In the same way many examples may be given of the extent to which the peculiar habits of a people create a demand for a peculiar class of merchandise. It is only

those who study the habits of the people who learn what these wants are, and who make a profit by supplying them. Here is an odd example. Not long ago a manufacturer in one of our great manufacturing towns found that a very large demand for blue linen pocket-handkerchiefs had sprung up in **Roumania.** The manufacturer made many thousands of such handkerchiefs, but for a long time he was unable to account for the reason for the demand. At that time, at any rate, the Roumanians were not famous for using pocket-handkerchiefs in the ordinary way, and a picture exhibited at one of the galleries at Berlin, representing only a pair of hands with ten fingers held up, was labelled underneath with the following inscription : "*The knife, fork, and pocket-handkerchief of the Roumanians*," which was as much as to say that the Roumanians used their fingers when they had better have used their pocket-handkerchiefs. But the fact remains that the Roumanians certainly do require and use a great number of blue pocket-handkerchiefs, and the manufacturer, being of an inquiring turn of mind, visited the country and at last found out the explanation of the matter.

It appeared that it was the custom of the country whenever a friend died to attend his funeral and shed, or appear to shed, tears of sorrow beside the grave. Everyone cannot shed tears when he wishes, but everyone can hold a pocket-handkerchief to his eyes as a sign of affliction. And this was what the good Roumanians did, and, when the ceremony was over, custom demanded that the pocket-handkerchief should be thrown into the open grave. To perform this office, therefore, it was necessary in the first place to possess a pocket-handkerchief, in the second place, as the pocket-handkerchief was never to serve again it was desirable that it should be a cheap one, and the blue handkerchiefs to which we referred, being apparently considered very suitable under the circumstances, were purchased in

enormous numbers for Roumanian funerals, and hence the explanation of this strange demand. This story is an odd one, but it serves as an illustration of the truth that a merchant must be wide awake, and must study the habits of his customers very closely in order to be able to anticipate their wants and to supply them.

Summary.

1. Commercial geography includes a knowledge of—
   (*a*) the distribution of commodities,
   (*b*) the means by which they can be brought to market,
   (*c*) the conditions under which they can be found,
   (*d*) the cost of obtaining the commodities when found.*

2. Commercial geography also includes a knowledge of the peculiar wants of the various peoples in different parts of the world.

3. A knowledge of the best means of communication is an important part in commercial geography.

4. The methods of communication change from time to time; such changes have an important effect upon commerce.

* The cost of transport and sea freights given in this chapter were correct at the time they were set down; the figures are, however, liable to changes from day to day.

CHAPTER XXI.

THE CONNECTION BETWEEN GEOGRAPHY AND HUMAN LIFE AND OCCUPATIONS.

A Country and its People.

WE shall have read this book to very little purpose if by the time we reach this chapter we have not discovered that the science of Geography deals with subjects which very closely concern the life of man. *Both men's minds and men's bodies are alike affected by the character of the country in which they live.* The history of a people will often depend in a large measure upon the nature of the land in which they live. The people in a **hot country** will differ in many respects from those in a **cold country.** A country with a large **sea-board** will produce a seafaring population. A **mountainous** country will be inhabited by a race of mountaineers, whose lives will in many ways be influenced by their surroundings. The materials of which the earth under our feet is made will also have their influence upon the lives and occupations of men.

The **geology** of a country helps to form the habits and occupations of men in all parts of the world. In our own country we find many examples of the way in which the character of a country in which a man dwells, shapes and influences his life.

The Highlanders.

We have said that it is a rule that dwellers in a mountainous country owe something of their character to the surroundings among which they live.

We need not go outside our own island for an example of this rule. On the west side of England and on the north of Scotland we have two great mountainous districts —the mountains of **Wales** and the Highlands of **Scotland.** Now it will be found that wherever a mountainous district exists, it is for a long time more or less inaccessible to those who live in the plains outside it. The passes by which it is approached are narrow, and capable of being defended against an enemy. The glens and valleys of the mountains form secure retreats for those who wish to escape pursuit, and the absence of roads makes it difficult for an invader to overtake the inhabitants who know the mountain paths and are accustomed to climbing. All these things contribute towards ensuring for a time the independence of those who dwell in the mountain country. We shall also notice further peculiarities. In the first place the soil of such a country is generally poor, and its pastures scanty. There will be a time when the inhabitants, dissatisfied with the scanty resources of their land, will endeavour to obtain by force a part of the wealth of their neighbours, and will descend into the plain to take it. Those in the plain will in due course resist, and will follow the mountaineers to their homes.

The Fortunes of the Border War.

For many years the border warfare between the hill folk and the low-country folk will perhaps continue with varying fortune; first one side and then the other getting the upper hand. Then at length a time may come when the low-landers, by some great effort, will break a way into the mountains, will master their rivals, and build roads through the mountains, and defend them by garrisons.

Such a history as this will naturally leave its traces behind it, and in such a country there is almost sure

to be the tradition of many battles, and of a long resistance to a common enemy, a tradition which will last as a popular sentiment long after all real hostility or cause for hostility has passed away. With the recollections of victory and defeat will probably go a custom of recording each change of fortune in song or verse. The dark caves, the mountain mists and thick forests, above all, the solitude which is inseparable from life in a mountain country which has not yet been opened up by roads, will always give rise to a spirit of superstition, and the poet and the ballad-singer will naturally give form to the feelings which are common among the people.

The history of **Wales** and the history of **Scotland** have been of the kind which we have described; and in both countries the influence of the past is still to be seen plainly written in the circumstances of the present. For many hundred years the Welsh and the Scotch mountaineers alike maintained their position with more or less success against the invader, and during the struggles which took place there grew up among both Welsh and Scotch tribes a rich literature of song and rhyme, which has deeply marked the character of the people who still preserve it. It is true that, both in Wales and the north of Scotland, the peculiar character of the inhabitants is very much less marked than it was. But this is owing to the fact that the influence of the physical features of the country has been greatly lessened, and the protection which the absence of roads formerly gave has been removed by the incoming of railways and roads. Nevertheless, it is true that wherever we find a mountain country there we shall find also a population whose character bears very plainly the mark of their mountain life. So, too, with other physical peculiarities of a country. The very fact of Great Britain being an island has left its mark upon every page of our history, and has made us the great seafaring nation of the world.

Men of Devon.

There is one great English county, bordered on two sides by the sea, whose south coast is indented for the whole of its length by sheltered harbours. The county of Devon has beyond all been the county of seamen. If we look in the list of great Englishmen in "Fuller's Worthies," we shall find that the list is longest under the heads of **Yorkshire** and **Devon**, and in Devon it is the sailors who give the greatest distinction to the list. There are not many towns of the size in England which can fill the windows of its Town Hall so worthily with illustrations of the doings of its citizens as Plymouth has done. The famous names of **Drake, Frobisher, and Raleigh** will show what the salt water has done for the men of Devon, and what the men of Devon have wrought on the salt water for their country. [21]

This chapter might be greatly extended, but enough has been said to suggest to those who read it a study which will prove of interest and importance. We can find in every country and in every district some example of the connection between the geography of that country or that district and the daily lives, the characters, and the habits of the men and women who live and work within it.

CHAPTER XXII.

STATISTICAL GEOGRAPHY.

WE said in an earlier portion of this book that there was a part of the study of geography which might be described as **Statistical Geography**. There are many facts and figures connected with any country with which it is useful to be acquainted, and many of which it is well to commit to memory if possible. Such are statistics of area, population, the position of towns, the direction of rivers, facts about temperature, products, and a variety of other pieces of information which may be obtained in any good Gazetteer. The student of geography may learn many of these statistics by the diligent use of a book and an atlas, but he will find that the most practical and useful way of learning them is by keeping his eyes and ears open when he is travelling, making a note of what he reads in the newspapers and in books, and taking care to understand as he reads the position of the places which are referred to. **History** should never be read without an atlas; **politics** cannot be understood without a knowledge of geography; and the same is true with regard to **commerce** and **navigation.** Directly we begin to study any one of these branches of knowledge we shall meet with a variety of details as to names, positions, population, and so on, details which we shall remember because they form a necessary part of an interesting study, and which we shall retain the longer because we have not learnt them merely by rote. Still there are some important statistics with regard to every country which it is necessary to learn by heart and

remember, and we shall give in this chapter a few statistics, with regard to one country, namely England, which will serve as an example of the kind of information which has been referred to.

England—Situation, Size, and Population.

England, including the principality of Wales, is the southern part of the island of Great Britain. It is situated between longitude 1° 46′ E. and 5° 47′ W., and between latitude 49° 57′ 30″ N., and 55° 42′ N. Its extreme length from Berwick-on-Tweed to the Lizard is 360 miles, and its extreme breadth from St. David's Head in Pembrokeshire to the Naze in Essex is 280 miles. The area of the kingdom is 58,378 square miles. The population by the census of 1891 is 29,001,018.

Comparison with Other Countries.

In order to get some idea of the size of England it is necessary to compare it with other countries. Fig. 102 shows the relative proportion of England and of other parts of the British Empire. It will be seen at a glance how insignificant in size is our little island as compared with Canada, Australia, and India. India alone is twelve times the size of Great Britain; New Zealand is about the same size; the colony of British Bechuanaland, about which the world hears very little, is also about the same size as England. In population, however, the United Kingdom still takes a very great lead over all the other English speaking parts of the Empire put together. Thus the population of the United Kingdom is returned as thirty-seven millions, while that of all the English speaking people in the rest of the Empire does not exceed nine millions. In time, of course, these proportions will be changed, and, in population, as in area, our great British possessions will outstrip the old country; but that time has

not yet nearly arrived.* Nor can anything deprive the "old country" of its wonderful position on the edge of the

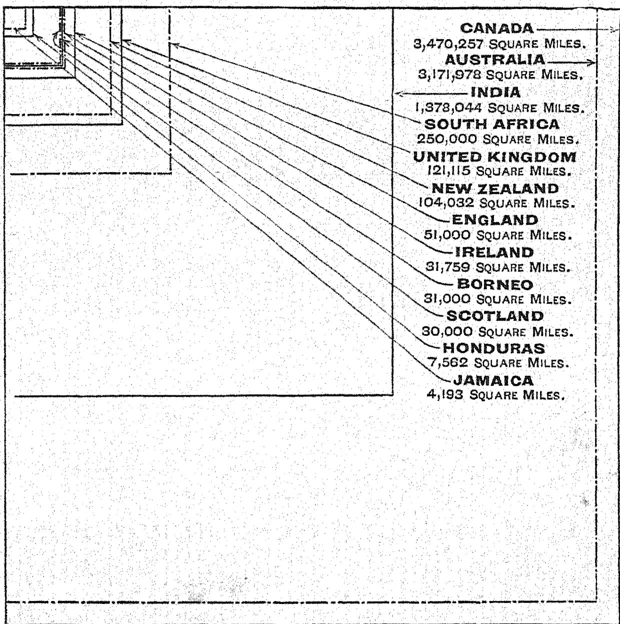


Fig. 102.—Diagram showing Comparative Areas of the United Kingdom and Principal Countries within the Empire.

continent of Europe, or its great history which will always be the common property of Englishmen.

Coast-Line.

The **Coast-Line** of England and Wales is nearly 2,000 miles in length. Taking into consideration the area of the

* England is the most densely populated of any country with the exception of Belgium, there being no less than 389 persons to a square mile.

country, this is a very extended line. We have in fact **one mile of coast** to every **twenty-nine square miles of surface.** If we contrast the coast-line of England with that of France we shall at once see what great superiority we enjoy in this respect, for while our own coast-line is nearly 2,000 miles in length, that of France, a country which has an area of 164,800 square miles, is only 1,600 miles in length; that is to say, **one mile of coast to 130 square miles of surface.** When we add to this the fact that the coast-line of Scotland is 2,500 miles, and that of Ireland 2,000 miles, we shall understand why it is that the inhabitants of our islands have become the first seafaring people in the world. No part of England is more than 120 miles from the sea, and many which are not actually on the sea are connected with it by navigable estuaries or by canals.

Temperature of England.

The mean annual temperature of England is 49·7°. The average summer temperature is 60·8°, the average winter temperature is 39·5°, a range of temperature between the mean of summer and the mean of winter of 21·3°.

Principal Divisions—The Counties.

The principal political divisions of England are the **counties.** Of these there are 40 in England and 12 in Wales. Many of the names of the English counties are of great antiquity, and date from a time previous to the Heptarchy, 600 A.D. Such are Sussex, the county of the **South Saxons,** Wessex of the **West Saxons,** Wilts of the **Wiltsæters,** Essex of the **East Saxons,** and so on. The arrangement of each county in its present form was, in the main, the work of King Alfred, though alterations and additions have since been made. On the eastern side of the country the limits of the counties are as a rule fixed by the physical formation of the country. Thus the Tyne, the

Tees, the Humber, the Wash, the Stour, and the Thames separate the counties of Northumberland, Durham, Yorkshire, Lincolnshire, Norfolk and Suffolk, Essex, and Kent, respectively. On the west and on the Scotch border the divisions have, as a rule, been regulated by political and not by geographical considerations.

The old sub-divisions of the counties still remain, though for administrative purposes they have been altered or superseded. In the greater number of the English counties there is a sub-division into **Hundreds.** In Yorkshire, Lincolnshire, and Nottinghamshire **Wapentakes** take the place of the Hundreds; in Northumberland and Westmorland there are **Wards**; in Kent we have **Lathes**; and in Sussex we have **Rapes**—as, for instance, the "Rape of Shoreham." It must not, however, be forgotten that on the top of these old divisions there is now a sub-division of the whole of the country for administrative purposes, into **Electoral Districts** for the purpose of electing Members of Parliament, **School Districts,** and **Poor Law Divisions.**

Ecclesiastical.

Still older than the county divisions are the **Ecclesiastical Divisions,** the smallest of which, that of the **Parish,** has continued since the first establishment of Christianity in our island. The date of the various **Bishoprics** varies, many of them being quite recent. England is also divided for ecclesiastical purposes into two **Provinces,** north and south, known as the Provinces of **York** and of **Canterbury.** But the divisions of the bishoprics have no longer any great importance, whereas the division into parishes, originally the work of the Church, has become accepted for several purposes, and is now the unit for almost all administrative or political purposes. There are thirty-four **Dioceses** altogether, nine in the Northern, and twenty-five in the Southern Province.

Chief Towns.

The principal **Towns** of England are as follows :—

TOWN.	COUNTY.	POP.
London, on the Thames.	Middlesex.	4,211,256
Liverpool, on the Mersey.	Lancashire.	517,951
Manchester, on the Irwell.	Lancashire.	505,343
Birmingham.	Warwick.	429,171
Leeds, on the Aire.	Yorkshire.	367,506
Sheffield, on the Don.	Yorkshire.	324,243
Bristol, on the Avon.	Gloucester.	221,665
Bradford.	Yorkshire.	216,361
Nottingham, on the Trent.	Nottingham.	211,984
West Ham.	Essex.	204,902
Kingston-on-Hull, on the Humber.	Yorkshire.	199,991
Salford, on the Irwell.	Lancashire.	198,136
Newcastle-on-Tyne.	Northumberland.	186,345
Portsmouth.	Hants.	159,255

Of the total population of England no less than 20,802,770 live in towns,* leaving 8,198,248 for the country population.

Products.

In the matter of its products England may be roughly divided as follows :—

Grazing Counties. — Northumberland, Cumberland, Durham, Yorkshire (North and West Ridings), Westmorland, Lancashire, Gloucester, Somerset, Derby, Stafford, Leicester, Shropshire, Worcester, Hereford, Monmouth, Wilts, Dorset, Devon, Cornwall.

Corn-growing Counties. — Yorkshire (East Riding), Lincolnshire, Nottingham, Rutland, Huntingdon, Warwick,

* The town population is that residing within urban sanitary districts.

Northampton, Cambridge, Norfolk, Suffolk, Bedford, Bucks, Hampshire, Hertfordshire, Essex, Middlesex, Surrey, Kent, Sussex.

Coal-producing Counties.—Durham, Northumberland, Cumberland, Westmorland, Cheshire, Lancashire, Yorkshire, Derby, Nottingham, Warwick, Leicester, Stafford, Shropshire, Gloucester, Somerset, North Wales, South Wales.

Iron ore is raised in the counties of Cornwall, Devon, Somerset, Gloucester, Wilts, Oxford, Northampton, Lincolnshire, North Staffordshire, Lancashire, Cambridge, Yorkshire (North Riding), Northumberland, Durham, Monmouth, South Wales; it exists also in other places, as for instance in Sussex, where it is not at present mined.

Lead is found in the counties of Durham, Northumberland, Montgomery, and Cardigan.

Tin is mined in Cornwall and Devon. **Silver** is usually found together with **Lead.** **Gold** is found in paying quantities in Wales. Cheshire is the principal district for **Salt.** **China-clay** comes from Devon and Cornwall; **Fire-clay** from Northumberland, and from South Wales.

The great districts for the manufacture of **Textiles** are the north and west.

A Lesson from Bradshaw.

It is impossible, and it would be useless to attempt to give any list of the towns of England and their positions. The best way of acquiring such information is to visit the towns, but this is not a method which is open to everybody. Perhaps the easiest way of acquiring a large amount of correct information about the position of our English towns and villages is to make a careful study of a **railway guide** and a **railway map.** Fig. 103 is familiar to all those who have occasion to study **Bradshaw's Guide.** It is a rough guide to the railways of England, starting from the great centre of London. The lines are placed in their correct

order radiating from the centre, but the information that the plan gives can be supplemented to any extent by those who

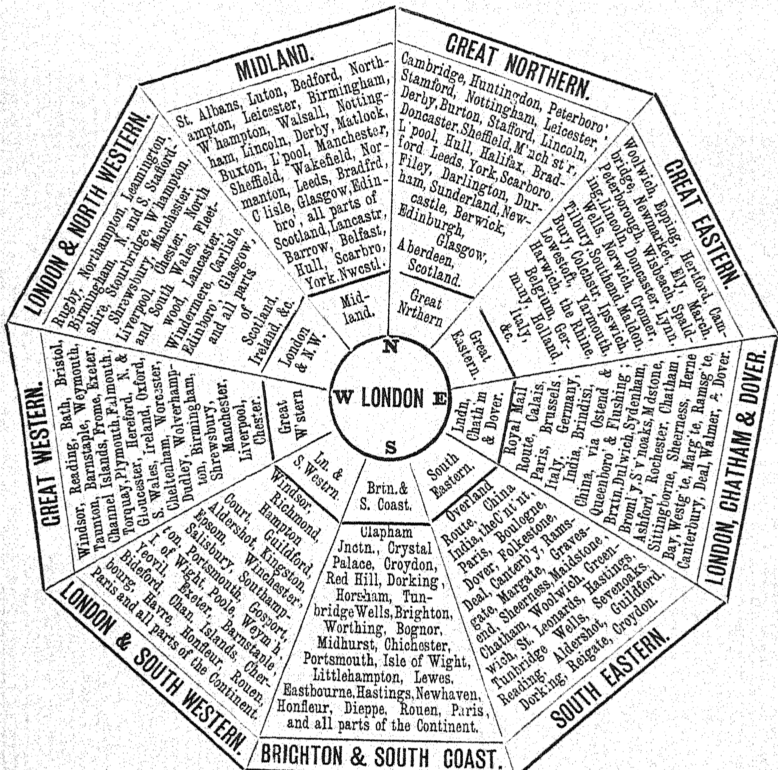


Fig. 103.—A Guide to the Railways of England.

have a taste for the study of Bradshaw's closely-packed pages.

A very good geography lesson can always be made by setting problems from Bradshaw, and a thorough knowledge

of the running and stoppages of the trains on our great trunk lines will do more to fix in the memory the positions and distances from one another of our English towns, than many an hour spent in poring over a gazetteer, or in the unaided examination of a map of England. [22]

Such are a very few statistics of one country. As we have said they are included here only to give an idea of what is meant by "Statistical Geography." A knowledge of statistics is not a knowledge of geography, but there can be no complete knowledge of geographical science save by a student who has his mind fully stored, but not overladen, with ordinary statistics.

NOTES.

(1) This and the succeeding chapters should be read with the assistance of as many of the ordinary appliances for geographical teaching as can be obtained. A globe is, of course, essential; an orrery is almost equally so. Many admirable appliances for simplifying instruction with regard to the position and movement of the earth, the sequence of day and night, eclipses, etc., can now be obtained at a very low price. Where not obtainable, a little ingenuity will usually suffice to produce a set of improvised apparatus which will serve the purpose.

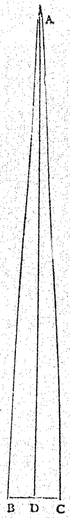
(2) The exact meaning of the word Zenith should be fully understood, and practical experiments should be made of the use of the telescope or of a smaller appliance as a ruler or a pencil, illustrating the various angles formed between the zenith line and the line of sight of the observer from any point.

In the same way the actual meaning of the word Horizon should be carefully explained. The use of the artificial horizon should also, if possible, be made clear, and the position of the horizon line on the actual surface of the globe should be clearly demonstrated.

(3) It must be borne in mind in looking at Figures 14, 23, and 26 that owing to the immense distance of the sun from the earth, and the comparatively insignificant distance from the equator to the pole of the earth, the horizontal lines may, for all practical purposes, be considered to be *parallel* and not convergent.

(4) A perfectly clear understanding of the meaning of the ordinary terms used in Geometry is necessary for the proper comprehending of this chapter. The reader must also learn to regard angles not merely as figures upon paper, but as forms of measurement in constant use in everyday life. A hundred opportunities can be found of taking angular measurements between actual bodies, and results of such measurements should be transferred to paper. A variety of simple experiments in the measurement of angles, distances, and of surface may be made by the use of an improvised apparatus made from paper or cardboard. Of course, such lessons are made much more valuable if they can be supplemented by actual instruction in the use of the sextant, the theodolite, and the level. An obvious

experiment suggests itself in the practical measurement by means of angles by any distant object which can be easily reached or of which the actual distance can be subsequently verified. Very fairly accurate observations of distance can be made with the aid of a roughly measured base and angles shaped out of pieces of paper. For further instructions as to a variety of experiments of this kind see Paul Bert's "Experimental Geometry," English Edition. Price 1s. 6d. (CASSELL & Co.).



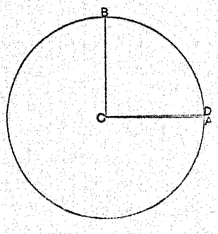
(5) The problem involved here is as follows:—Given an isosceles triangle, A B C, with base equal to 1 and sides equal to 10. What is the value of the angles at the base? The following is the solution:—

If BC = 1 and AB = 10 $\frac{BD}{AB} = \frac{\frac{1}{2}}{10} = \frac{1}{20}$ = 0·05 = cosine 87° 8′ nearly.

$\frac{87^\circ\ 8'}{174^\circ\ 16'}$ 180 − 174° 16′ = 5° 44′.

(6) Throughout this chapter the term "arcs of degrees" has been used when speaking of the degrees used in measuring the earth's surface. It is of course obvious that the earth being a globe, the degree drawn over its surface must be an arc of a large circle. The fact necessitates a knowledge of Spherical Trigonometry in accurate calculation of terrestrial measurement, but for the purpose of the present book such a knowledge is not assumed. It is important, however, to remember that the terrestrial degree is an arc, and not a chord of an arc.

The following is a fuller definition of a degree than that given at the end of this chapter.



DEGREE.—A small angle, the ninetieth part of a right angle ∟. If a right angle be placed in a circle as in the figure, and a line CD be drawn from C, making an angle of 1° with CA, then the arc AD is the ninetieth part of the arc AB which is opposite the right angle ACB; and the arc of 10° will be ten times the arc of 1°, and so on. This is the reason why the arcs, which change as the angles change, are used in geography to measure angles. A circle is divided into 360 degrees.

(7) In 1889 the Vernal Equinox was on March 20, at 10 a.m.
In 1890 ,, ,, ,, ,, ,, ,, ,, ,, 7 p.m.
In 1891 ,, ,, ,, ,, ,, ,, ,, ,, 9 p.m.
In 1892 ,, ,, ,, will be on March 20th, at 3 a.m.

(8) In taking this and any similar observation of the sun, allowance must be made for the height of the observer above sea level, or the level of the horizon, otherwise it is obvious that the angle S C H, Fig. 74, will be really more than a right angle.

(9) At a conference held in 1891 it was unanimously agreed to recommend the adoption of the English meridian in all maps and charts.

(10) Another definition of the Meridian of Greenwich may be given as follows:—A plane drawn exactly north and south, passing through the zenith of Greenwich and the two poles.

(11) In connection with this chapter it will be well to make a series of calculations of the difference in time between Greenwich and various other places, reckoning the time from the known longitude of the place, and conversely to calculate the longitude of different places, their times as compared with midday Greenwich being given. Thus, given the longitude of New York, find out the difference between New York and Greenwich time; or, given the difference between Dublin time and Greenwich time, find out the longitude of Dublin.

(12) The object of the chronometer is to show the correct time in all climates, for the parts of an ordinary watch expand with heat and contract with cold, thus altering the tension of the spring, and consequently the regularity of the movement. In a chronometer, a "compensating balance" is introduced. There are many varieties of such balances, but the principle of all of them is the same. Two materials are introduced having different rates of expansion and contraction, and so arranged that the expansion of the one in any given condition of temperature is "compensated" for by the contraction of the other, and *vice versâ*. The balance is connected with the regulating spring of the chronometer, and thus the instrument is automatically regulated in passing from one temperature to another. Balances have been made of glass and of various kinds of metals placed side by side. A mercurial balance, depending for its value upon the contraction and expansion of the mercury, has also been used.

(13) The following is a correct account of the process of taking an observation on board a man-of-war:—On board a man-of-war the navigating officer, or, as he is often called, the "master," breakfasts punctually at eight, and immediately afterwards repairs to his chronometer room, and carefully winds the three chronometers with which his ship is provided. The fact that the chronometers are wound is then reported to the captain. At the same time, the master compares with the chronometers a reliable watch, known as a "deck-watch," and ascertains the difference between the times shown by them respectively. This done, to avoid the necessity of taking the chronometer on deck he takes his sextant, and summons his

assistant, who, taking charge of the deck-watch, accompanies him on deck, and a convenient spot for making the morning observation, or, "taking a sight for longitude," is selected. If you were watching the master you would see him raise the sextant to his right eye, holding it with both hands, and look at the sun through it: he would then, still keeping his eye to the sextant and moving the arm of the sextant with his left hand, gradually alter its direction until he appeared to be looking at the horizon. This is called "bringing the sun down" to the horizon. His next step would be to screw a short telescope into the sextant, through which he would again look at the horizon, this time carefully manipulating, with his forefinger and thumb a screw attached to the arc of the sextant.

Presently he will say to his assistant who holds the watch, "Stand by!" The latter will at once begin counting to himself the seconds as marked by the watch, thus, "twenty-two, twenty-three, twenty-four." The master having now obtained an exact "contact" between the edge of the sun and the horizon, calls sharply "Stop!" and takes the sextant from his eye. The assistant at once enters in his note book the seconds, the minutes, and the hour, and the master reads off from his sextant the angle which he has observed, and which is the altitude of the sun at that instant.

The entry may read thus :—8 h. 34 m. 24 sec. 39° 21′ 10″.

The master again raises his sextant, and by this time, though not half a minute has elapsed, a considerable gap appears between the edge or "limb" of the sun and the horizon; carefully the two are again brought together: "Stand by," "Stop," and another sight has been taken. This process is repeated three times, and if not quite satisfied with the observation, another "set" will be taken by the master.

By this time a goodly number of sextants and watches will have appeared on the scene, for on a man-of-war all the executive officers have to make their observations, work out the ship's reckoning, and report the result to the captain, daily.

The sun is now left in peace till about a quarter to twelve, when the instruments are again taken out, and every officer, down to the smallest midshipman, is again to be seen closely watching its movement. The same process of "bringing the sun down" is gone through, but the watch is not brought into play this time. The object is to measure the highest altitude reached by the sun that day, and this will of course be obtained at twelve o'clock noon. At that hour (apparent time) the sun will begin to come down again. All that is required, therefore, is to bring the sun down to the horizon with the sextant, and to keep it there by slowly increasing the angle on the sextant as the sun creeps up (for it is now moving very slowly) until at last it rises no more: the limb of the sun no longer separates from the horizon, it seems to stick to it. The master, who has from time to time been reading off his sextant and making calculations on his thumbnail or in his notebook, now puts the final touches to his figure, raises his sextant once more, and seeing that the limb is not only touching the horizon, but actually overlapping it, remarks "The sun has dipped." He then walks up

to the officer of the watch and reports, "Twelve o'clock, latitude 44° 16′ 30″." The officer of the watch reports "Twelve o'clock" to the captain, who replies, "Make it so, if you please." The officer orders, "Strike eight bells," "Pipe to dinner," and another day is added to the ship's log. The latitude having now been accurately obtained, it is possible to proceed with the calculation for obtaining the longitude from the morning observation, of which the latitude is a necessary ingredient. This calculation generally occupies about a quarter of an hour, and the ship's position as determined by the observation of heavenly bodies is in the captain's hands by half-past twelve.

(14) Any number of examples may be added to those given in this chapter. Map-making may be practised on a very elementary scale in the schoolroom, in a garden, or on any familiar piece of country. Laying down, and correctly observing the points of the compass, laying down places upon a map in their correct "bearing" with regard to each other, and "walking by the map," will all be found exceedingly useful exercises. Contouring may also be practised on a very small scale, and a useful and instructive amusement can be obtained by making small contour maps in plaster of any given piece of country. A simple method of producing such maps is to stick pins upon a board, the height of each pin representing the altitude which should be reached at any particular part of the map. The pins are then covered with plaster, and the surface reduced to the level of the tops of the pins, when an accurate contour representation of the surface required will have been produced. The use of the mariner's compass and a thorough knowledge of the points of the compass are also necessary with geographical instruction.

(15) Water takes a longer time to cool than land, chiefly because of its high "specific heat," *i.e.*, one pound of water in cooling one degree gives out thirty times as much heat as one pound of mercury does. This is also the reason why water takes a longer time than land to become hot.

(16) Cold is merely absence of heat. When the cold of an iceberg is felt, the sensation is merely due to the lower temperature of the ice. If it were possible for the human body to be colder than the iceberg, the approach of the latter would cause the feeling of warmth. Frost-bitten toes are colder than melting snow, and are actually gently warmed by the application of snow held in the hand.

(17) Constant readings should be taken of the thermometer and barometer, and if possible records should be kept. Great care should be taken to connect the readings of the instruments with actual temperatures, such as the temperature of the room, etc., and with the visible effects of barometrical pressure. The use of the "Vernier Scales" for measuring

small changes in the height of the mercury should also be clearly understood both in principle and practice.

(18) Other corrections have to be made when taking exact barometrical readings, for instance, allowance has to be made for "capillary attraction" and for the expansion and contraction of the glass tube, etc.

(19) The following is a brief summary of the Italian campaigns as illustrated on page 263. May 10th, 1796, Buonaparte, advancing eastwards from Piedmont on Mantua, forces the passage of the Adda at Lodi. May 30th, Buonaparte forces the passage of the Mincio at Borghetto, the Austrians retreat upon the Adige, opening the road to Mantua, which is accordingly besieged by the French. The Austrians sending reinforcements from the Tyrol by way of the Brenner Pass, reach Trent. Buonaparte, leaving the blockade of Mantua, turns to meet the Austrians advancing down the valley of the Adige, beats Quasdanowitch at the foot of the Lake of Garda, and drives the Austrians back into the Tyrol. The Austrians advance again, and are again defeated at Lonato. The relief of Mantua is thus prevented. Again the Austrians advance in force southwards through the defiles of the Brenta, and are again defeated at Roveredo (September 4th). The Austrians, advancing for the fourth time, by way of Trent, are beaten at Bassano (September 8th), and their general forced to try and find refuge in Mantua. Attacked under the walls of the city, he is defeated and driven into the fortifications. A fifth time a new Austrian army is sent through the passes of the Alps, and, descending again by way of Trent, carries the positions at the southern end of the pass. Buonaparte, marching hurriedly northward, defeats them at Caldiero, and again at Arcola (November 15th). In January, 1797, an Austrian army again descends by the same road to the relief of Mantua by the lines of the Adige and Brenta. Buonaparte attacks and defeats them at Rivoli (January 14th), and all hope of relief having been thus taken away, Mantua capitulates February 2nd.

All these battles, it will be seen, were fought at the mouths of passes. The next campaign gives more examples of battles fought to secure or to force the passage of rivers. The second Italian campaign commenced in 1799. In May of that year Buonaparte undertook the passage of the Great St. Bernard, St. Gothard, and Mont Cenis with three detachments of his army. On the 16th he reaches the top of the Great St. Bernard, and on the same day the French vanguard reaches Aosta on the Italian side On the 17th the first battle takes place at Chatillon, the fort of Bard makes a vigorous resistance, which for a time checks the French advance; the first object of the French being to relieve Genoa, at that time blockaded by the Austrians on land, and the English at sea.

Marching down the pass, the French defeat the Austrians at Ivrea and Chiusilla, opening the road to Turin. On the 9th the French defeat the Austrians at Montebello, cross the Po, and turning back in the direction of

Genoa, come upon the Austrians on the banks of the small river named the Bormida, where is fought the great battle of Marengo. Genoa having fallen, a further advance to the west is unnecessary, but, on the east, the French, having first forced the Adda, carry in succession the line of the Mincio and Adige, and once more possess themselves of Northern Italy from s a to sea.

(20) Although, as stated in the text, extreme temperatures are very rare in the United Kingdom, remarkably low and high readings of the thermometer have occasionally been recorded. The coldest district in the United Kingdom appears to be the valley of the Tweed, close to Kelso, where the significant name of "Coldstream" is to be found. In December, 1879, and January, 1881, readings of —16° Fahr. were recorded close to Kelso. It has also been stated that on December 4th, 1879, the thermometer at Black Adder, near Coldstream, fell to —23° Fahr., but there seems to be some doubt as to the authenticity of this reading. In the district referred to the temperature on a screen four feet above the ground occasionally falls to —16° or 48° Fahr. below the freezing point. With regard to maximum temperatures the hottest day recorded in recent years was the 15th July, 1881. On that day, two stations, namely, Alton in Hants, and Alderburg in Wilts, reported over 100° Fahr., and Greenwich gave 97° in a Glaisher stand. These temperatures were of course taken in the shade. There is much uncertainty with respect to the records of some maximum sun temperatures, but temperatures of 160°, as shown by a black bulb *in vacuo*, have been frequently reported.

(21) The windows in the Plymouth Guildhall have been filled with coloured glass representing some of the most remarkable incidents in the history of the town. There are few towns in England which could show so brave a record.

The subjects represented in the various windows are as follows :—

1. The Black Prince at Plymouth. 1355.
2. The descent of the Bretons on Plymouth in 1403, on which occasion 600 houses in the town were burnt.
3. Sir Francis Drake bringing the water from Dartmoor into Plymouth by the famous "Leet," commenced by Drake, and completed by the Corporation. The "Leet" is still the source of supply for the town.
4. The famous game of bowls played on the Hoe by the English captains at the time of the announcement of the approach of the Spanish Armada.
5. The arrest of Sir Walter Raleigh at Plymouth.
6. The "Cooksworthy" window, representing Cooksworthy, the Plymouth "Potter," with examples of the china made by him.

7. The "Opening Window," representing the opening of the present Guildhall by Albert Edward, Prince of Wales, Lord High Steward of the Borough of Plymouth.

8. The "Priory Window," representing an inquiry held in Plympton Priory Church in the year 1440, into the value of the property in Plymouth belonging to the Priory, which was to be transferred to the then newly created Corporation of the Borough.

9. Catherine of Aragon received by the Borough authorities on her landing at Plymouth, 1509.

10. William III. proclaimed in the old Guildhall; Plymouth having been the first town to pronounce in favour of the Prince of Orange. 1688.

11. The Departure of the Pilgrim Fathers from Plymouth Barbican. 1620.

12. The "Siege Window," representing the "Sabbath-day fight," an incident in the Siege of Plymouth successfully held for the Parliament against the King.

13. The "Buonaparte Window." Napoleon Buonaparte, with his suite, a prisoner on board H.M.S. *Bellerophon*, in Plymouth Sound, on his way to St. Helena. 1815.

14. The "Masonic Window," representing the holding of the Grand Lodge of Freemasons of Devon and Cornwall by the Prince of Wales, the day after the opening of the Guildhall.

(22) There is no end to the number of geographical lessons and problems which may be based upon the contents of Bradshaw or of any foreign Railway Guide.

Some examples are here given:—

1. The London and North-Western Railway runs to Glasgow through Tring, Bletchley, Blisworth, Rugby, Nuneaton, Stafford, Crewe, Warrington, Wigan, Preston, Lancaster, Penrith, Carlisle, and Carstairs.

   The Midland Railway runs to Glasgow through Luton, Bedford, Kettering, Oakham, Melton Mowbray, Nottingham, Sheffield, Normanton, Leeds, Skipton, Appleby, Carlisle, and Dumfries.

   Which is the shorter route? What are the principal natural obstacles passed through by either line? What mineral districts do they pass through? What are the probable reasons for the course taken by either railway: *a*. Physical. *b*. Commercial?

2. *A journey from London to Carlisle by the Midland Railway.*

Observe the change from one geological formation to another. The London clay on leaving St. Pancras; the cuttings through the ring of chalk which surrounds London. Mark the greensand near Bedford.

Again, a great feature of the line is that, running almost directly from south to north, it crosses the valleys at right angles. The greater number of English rivers run east and west, and *vice versâ,* hence the line is remarkable for the number of inclines. Leaving London it passes off the London clay, and cuts through the chalk downs near St. Albans. This is unavoidable, for the chalk downs form a complete range round London, save at Goring, on the Great Western Railway, where the Thames has cut a passage through the chalk.

Beyond Luton the line crosses the Chiltern Hills, at Bedford it crosses the Ouse, and the Nen at Wellingborough. It strikes the valley of the Trent at Nottingham and then passes through the centre of the coalfields, serving the great collieries of Ilkeston, Clay Cross, and Chesterfield; tunnels its way into and out of Sheffield, and again passes through the coal district of Cudworth, Rotherham, and Normanton to Leeds. Here at last the railway is able to take advantage of the course of a valley and runs north-west up Airedale to Hellifield. Here, however, it has to cross from the eastern to the western watershed of England, and a long steep climb takes it up to the top of the bleak Yorkshire moors, 1,100 feet above the level of the sea. Hence it begins to descend with the water to the Solway Firth, and finally makes its way to Carlisle along the valley of the Eden. For the greater part of its course, therefore, it will be seen that the Midland Railway is compelled to take its direction from the important towns which it has to serve, and gets little assistance from the natural contour of the country.

Observe the long cuttings through the Oolite between Kettering and Oakham; and through the Lias at Barrow-on-Soar. Mark the granite quarries on Mount Sorrel, near Loughborough, showing the point where the Silurian formation appears in the middle of England, and reproduces in the wooded slate and granite country round Mount Sorrel a miniature of Wales.* *Note the Trias* between Nottingham and Sheffield, the Permian at Sheffield. Mark also the entry into the coal country beyond Nottingham, and the various coal districts of Leicestershire, Derbyshire, Nottinghamshire, and Yorkshire. Observe the abrupt passage from the millstone grit to the mountain

* Barrow and Mount Sorrel are on the western branch, *viâ* Leicester.

limestone near Skipton, and contrast the flat or rounded form of the limestone mountains of Yorkshire with the pointed and jagged outlines of the lake mountains, which are visible on the long descent from the summit of Shap Fell to Carlisle.

Then again, looking at the line from another point of view, note the various manufactures carried on in the towns and villages passed through. Near London, brick making; Luton, straw plaiting; Wellingborough, ironworks; Nottingham, hosiery; Sheffield, cutlery (originally brought there by the plentiful supply of water power, and kept there by the plentiful supply of coal); Chesterfield and Masboro, coal; Leeds, coal, iron foundries, cloth making, leather making, &c.

Then again the watersheds traversed, and the valleys utilised by the railway should be marked; the points reached by canals, and navigable streams noted. The dividing line of the eastern and western watersheds observed, as for instance at Ribblehead, the watershed between Wharfe and Ribble.

Or the line may be used to furnish the basis of an historical lesson. St. Albans, the old Roman "Verulam," with the Roman bricks still in the structure of the Christian cathedral. Bedford, the town of Bunyan. Leicester, a Roman station, and one of the oldest of our midland towns. Nottingham, many times lost and won, the chief of the Danish fortresses of the Danelagh, and in every civil war a place of the highest importance as commanding the passage of the Trent. Derby (on the western branch of the main line) the southernmost point reached by the Scotch army in the "45," the last occasion when an armed enemy was seen on English soil, etc.

3. Plan out on the map of Europe the best and shortest routes from Calais to Salonica; and from Bordeaux to St. Petersburg; the line to avoid, as far as possible, natural obstacles, and to pass through as many large towns as possible.

Give reasons for the routes selected; compare them with the routes actually taken as shown by the continental time tables, and give the probable explanation of the political or other causes which have led to the adoption of the existing lines.

e.g. The natural course of the line from Calais to Salonica is to strike the valleys of the Rhine and Danube, passing up the one and down the other. This is the course taken by the direct expresses through Brussels to Cologne up the valley of the

Rhine to Mayence, across the angle between the Rhine and the Danube to Ingoldstadt, down the valley of the Danube to Vienna, Pesth, Belgrade, up the valley of the Morawa to Nisch, down the valley of the Varna to Salonica. With the exception of the somewhat difficult and rocky country in the Ardennes between Brussels and Cologne, there is no serious natural difficulty to be overcome on this line, and as the principal towns are situated in the valleys of the great rivers, the most favourable route in the engineer's point of view is also the most satisfactory from the commercial point of view.

4. Work out in Bradshaw the shortest routes from (*a*) Penzance to Wick, (*b*) Sligo to Lynn, (*c*) Southampton to Clitheroe, (*d*) Pembroke to Peterborough, (*e*) Dover to Stratford-on-Avon.

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